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Center for Nuclear Waste Regulatory Analyses
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TR08

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PROCEEDINGS

MR. GARRICK: Good morning. The meeting will now come to order. This is the second day of the 123rd meeting of the Advisory Committee on Nuclear Waste.

My name is John Garrick of the ACNW. Other members of the Committee include George Hornberger, Ray Wymer and Milton Levenson. ACNW consultants are Drs. Jim Clark and Rod Ewing. They're also in attendance with us today. The entire meeting will be open to the public.

Today we're going to hear a presentation by center staff, and on the Yucca Mountain TPA, Total Performance Assessment Code and External Review.

We're going to hear a presentation by NRC staff and the center on capability of NRC staff to evaluate risk significance of information submitted by DOE for postclosure.

We're going to discuss in here a presentation by the center staff on preclosure safety analysis, or at least on the preclosure safety analysis tool. Review alloy C-22 studies by DOE and the center. Hear a briefing and discuss the draft plan for research, supporting the nuclear waste safety area.

And we're continue our discussion and work on proposed ACNW reports. That's a pretty loaded agenda.

Andy Campbell is the designated federal

official for the initial portion of today's meeting. This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act.

The Committee has received no written statements from members of the public regarding today's session. And should anyone wish to address the Committee, please make your wishes known to one of the Committee staff.

If you make a statement, it's requested that each speaker use one of the microphones, identify themselves, and speak clearly in a volume so that it can be readily heard.

All right. I think without any delay, since we gave a rather comprehensive introductory remarks yesterday about what we were trying to achieve with this meeting, we will not repeat that, and we will move directly into our first presentation, which is on the Yucca Mountain TPA Code and External Review. And it's my understanding that Jim Weldy of the center will be the lead-off presenter.

MR. WELDY: Thank you, Dr. Garrick. My name is James Weldy, and I'm a member of the performance assessment group in the CNWRA, and I'm going to be talking to you about the external review of the TPA Code, and my colleague, Tim McCartin will be discussing the current plan of capabilities in the code group.

The outline that I'll first off describe the peer review as conducted of the Version 3.2 of the TPA Code. I'll discuss the development of an action plan for responding to these comments, and then give you a current status of implementation of that plan; how we're coming and who's funding the comments so far.

The peer review of TPA 3.2 was conducted during the summer of 1999, which documents the strengths and weaknesses of the TPA Code, and to evaluate the suitability of the Code for use in reviewing the DOE license applications.

We selected -- we attempted to select the members of the external review through peer acclimation process; wherein, we sent nomination forms to a large number of experts in the field, in the various type of disciplines that we wanted experts from.

We received nominations and attempted to select the person who received the most nominations from the various experts. And unfortunately, we did run into some problems with availabilities of the experts, and problems with conflict of interest, such that the person who received the post nominations was not always available to serve on the panel.

And in some circumstances, in fact, none of the people who were nominated were able to serve on the panel, and we were forced to nominate the NRC work force staff to nominate other experts, who we felt were capable in the area, in order to perform the peer review.

MR. GARRICK: How did you get the candidates in the first place? How did you identify them?

MR. WELDY: It was really just a matter of we sent a -- you know, to a very broad number of people in the field that we were familiar with. And this was sent internationally to -- I think there were 120 total people who were initially selected for the nomination process, and people were allowed to nominate themselves as well, if they thought they were able to serve on the panel.

MR. GARRICK: So there was a formal announcement of -- that asked people to nominate themselves if they so wished?

MR. WELDY: That was one of the options included on the form that we sent out to all these people.

MR. GARRICK: Okay. Thank you.

MR. HORNBERGER: How many responses did you get of the 120?

MR. WELDY: I'm going to have to give that one off to Gordon. I'm not sure.

MR. WITTMEYER: I'm Gordon Wittmeyer. I don't recall the number of responses that we got from the 120 or more letters that we sent out. I would say it was a little bit less than half.

We probably received over a hundred names of potential experts. And I think most votes that any one person was probably six or seven. That gives you a rough idea. I think the numbers are actually in the report, if you have copies of that.

MR. GARRICK: Yeah. Yeah. The decision as to who, except for those that nominated themselves were made by the center staff and the NRC; is that right?

MR. WELDY: Well, the desire was to take the people who got the most nominations.

MR. GARRICK: Yeah.

MR. WELDY: But when those people weren't able to serve, due to availability or conflict of interest concerns, we either -- we went down the list until we ran out of people on the list. And that point, we were forced to nominate people ourselves between NRC and CNWRA staff.

MR. GARRICK: Okay. Thank you.

MR. WELDY: The conduct of the review was -- we sent the Code documentation to the experts for their review in early June of 1999. This consisted of the user's guide for the TPA 3.2 code, and also a sensitive studies analysis conducted on the code, which hopefully allowed them to see what the important areas of the code were, and get an idea -- a better idea of how the code was actually running and working in the word processes involved in the code.

They had about a month and a half to review the documentation prior to the formal meeting that we had. And several of the experts submitted questions during that time. Questions for clarification, on how things were working, or what we were doing, which we responded to prior to the formal meeting.

MR. GARRICK: I'm sorry, Jim. I want to make sure I understand this. The documentation, was it all NRC documentation, or did it include DOE material, such as part of the TSPA?

MR. WELDY: It was just on our see documentation. It was two documents related to the TPA Code specifically. It did not -- we did not send them the full slew of documentation that we had about all of the detailed process level models that went into the development of the code and supported the code.

We limited it to just the user's guide and the sensitivity studies report, because we didn't want to overload them with too much information, since it would've been --

MR. GARRICK: Yes.

MR. WELDY: -- boxes and boxes and boxes, which they would've had a very difficult time going through completely.

MR. GARRICK: That was the one thing I was curious about, is how much of this documentation would help them understand enough about the repository itself to, you know, be able to make good judgments about the representativeness of the models of the site.

So I was curious as to how much site information, for example, they might have received.

MR. WELDY: The user's guide has some information on site characteristics, but beyond that, there wasn't any additional site information sent to the experts.

MR. GARRICK: Okay.

MR. HORNBERGER: Except the -- if you look at the report, it's clear that all of your experts consulted lots of documents including DOE documents, and USGS documents in conducting their review.

MR. WELDY: Yes. Many of them were already, at least in some aspect, familiar with the program. And they were certainly went out on their own and found any information that they needed to conduct their review.

In late July 1999, we held the formal meetings for the experts, during which we made presentations on the code, and we encouraged the experts to ask questions for clarification, or that they had any additional information that they wanted. And we attempted to get all the experts together at one time, so that they could -- so questions from one expert could feed the questions and lead to active discussion among the experts.

We were able to get seven together at one time, but due to limited NRC and CNWRA staff availability in one technical discipline, we were forced to have one of the experts have an individual review; have an individual presentation session.

MR. GARRICK: I've already apologized for interrupting. How much -- you said that you were able to get seven of the experts together at one time. How much time together did they spend?

MR. WELDY: It was most of a week.

MR. GARRICK: Uh-huh. So there was interaction and cross-talk and --

MR. WELDY: There was a lot of interaction and cross-talk. There was very lively and interesting discussions.

MR. GARRICK: That didn't come through the report as much as I would've expected. Because that's one of the things we were a little concerned about, is just how effective this could be, because it had the appearance of being somewhat isolated; each expert being somewhat isolated. And not having the advantage of exchange. So

I'm very pleased to hear that.

MR. WELDY: Yeah. That was probably one of the main goals --

MR. GARRICK: Yeah.

MR. WELDY: -- of the large meeting, was to get them all together, so they could feed each other with the active discussion.

MR. MCCARTIN: Tim McCartin, NRC. Also at that meeting, we were, the staff, NRC and center staffs were making presentations to give them a sense of the regulation and they would ask questions about the regulation. What we understood about the Yucca Mountain Code, et cetera, so there also were in that -- there was that interaction between --

MR. GARRICK: That's good.

MR. WELDY: The expert review group consisted of members with expertise in a number of different technical areas. We attempted to select people with expertise in areas that covered all of the main important processes modeled in the TPA Codes, so there could be a thorough review given to the code.

And we selected experts -- people with expertise in rock mechanics and mining engineering, rockanology (phon.), hydrology, a drill site and corrosion engineering, geochemistry, health physics and then two people with more of a general background of an overall assessment, and then FEPS analysis. We thought that would give a very full coverage of the code, and would lead to an excellent type of a review of what's in the code.

Following the meetings, the experts were asked to write up a report, documenting their findings of the review. In which they were asked to examine the methods and assumptions made in the TPA Code, make any recommendations for improvements for future versions of the Code, evaluate how we implemented our conceptual models, including which parameters choices we made. And make some sort of assessment as to whether the NRC approach to the EPA was sufficient to review the DOE license application.

This is why in some of the discussions on the regulatory framework were important in these meetings, because we did ask them to make some sort of an assessment, as to whether our code would be sufficient to -- for the NRC to use as a tool, and evaluate the DOE's license application.

And then each expert submitted an independent review report. It was not a consensus report, because we wanted to get all of the suggestions that all of the experts had individually, and then we would compile them in determining which ones we wanted to implement ourselves, rather than having them decide outside which ones they thought were the most important.

The overall impression that we got from the reviews was that the code was very well developed, and captured the important physical processes associated with the repository very well. And there was general agreement within the reports that the code, with some improvements, would be sufficient in technical quality and flexibility to review the DOE's license application.

So, in general, the reports were pretty positive and we thought, gave us a good -- pretty good confidence that we would be able to review the DOE's license application with the code.

Of course, they did have a number of suggestions for improvements. There was -- these suggestions covered a wide variety of areas. Some of the issues that came off on -- numbered different of the reports included things such as the level of code documentation, placability of the analyses, documentation of our FEPS analysis. Items such as this, where the TPA Code fell within the regulatory framework.

There are a number of comments on that. There were a number of comments on how we were modeling a couple of processes and the level of decoupled that we put into the code, and whether that was appropriate.

There was one fairly serious comment about our lack of data in the saturated zone modeling.

One expert felt that we really didn't have enough data to support the model that we used for our saturated zone model, which is a concern that we have also voiced to DOE in the past, and continue to voice to DOE.

So we do expect to collect more data and will improve the model as necessary, as additional data comes in.

There were -- a number of experts indicated that the basis for selecting the rated new buds track (phon.) really wasn't sufficient. We really needed to be a little more explicit on how we selected those -- rating new buds that were tracked, and how we eliminated the ones that we didn't track.

And there were a number of experts who indicated we really didn't track and take into account the chemical composition of the water as well as we could, in various locations within the repository in the -- on the surface, the waste package, within the waste package, and the outside traded zone of the local repository. They thought we could do a better job of tracking the chemical composition, at least determining what it would be, and whether it would change the results, it needs to be tracked.

In order to reply to these comments, we developed an action plan, in which all the questions and comments of the -- about the applicability of the code when it's directed from these reports, they were grouped together, so similar comments could be addressed by a similar -- by a single response. And they were all assigned individual tracking numbers.

Each of these sets of comments were then sent out to the technical experts for the response, in order to document -- how we were going to respond to that.

This is an example of what the action plan looks like. You can see it assigns an identification number, and it indicates which reviewer made the comment. It quotes the comment from the report, it also cites within the report where that comment was made, so that if someone's coming -- just looking at this, they could go back to the original report, and actually understand what the expert is getting at.

Because sometimes when you just pull out a small segment of text, you don't really understand what they're going after, and we encourage the responders to do that, to go back to the actual comments, so that they could understand the expert was looking for.

The next four columns indicate the technical areas that were assigned to respond to these comments.

They were divided down by integrated subissue, which is a sublock within the TPA Code. And for a number of the comments, particularly those that dealt with -- and the level of coupling within the code, it required more than one technical area to respond to the comment.

And, as you can see, for 160 down there, some of them required a number of interaction between a number of different technical discipline, in order to fully respond to the comment.

MR. GARRICK: Has there been any attempt to map these into the KTI's?

MR. WELDY: There was an initial attempt to map them into the KTI's. We decided that the ISI was a more appropriate venue for responding to them.

Basically, because they map -- the ISI's map more directly to the TPA code, and it's the -- ISI is already involve a certain amount of coupling within themselves, so we felt that was a more appropriate way to respond to the comments.

So, in total, we had -- we came up with 234 unique comments from the external reviewer's reports. And this covered a wide range of technical areas.

And, as I said, the response may require input from multiple technical areas.

Generally, the plan is to respond to the comments using one of the following methods. The responders do have flexibility to choose their own way, their respondent comments as they deem appropriate. But most of them, we expect will be responded to either by indicating how the comment has already been addressed as a newer version of the TPA Code, TPA 4.0 and 4.1 have been released since the version that the external reviewers looked at, and therefore, some of these comments have already been addressed.

Another way is to cite a document, a sensitivity analysis that indicates the issue does not really have a significant affect on performance. A third way is to state that the issue will be addressed to future versions of the TPA Code. We're currently in the development phase of TPA 5.0.

Or finally, the technical expert could provide additional justification that assumptions made within the code, within the modeling, or within the selection of parameters are appropriate.

Current status of the external review is that we have completed full responses for approximately 25 percent of the comments. The number of the other ones, at least, partial responses, too, but need additional information or justification in order to be considered to be complete.

We plan on completing all of the responses by June of next year. And the responses may refer to work that has not been completed, even though all the responses will have been developed by then. We still -- it may say a future report, something that people are working on or will be working on in the next year or so, in order to respond to the comment.

The next couple of slides, I provided just a couple of sample responses that we've received so far, to give you an idea of the types of -- what we're doing to respond to these comments.

This first one refers to the chemical -- how we model our -- how well we know the chemical composition of water, particularly in the unsaturated zone. And says that using the J-13 water may not be appropriate to model, et cetera, in its own waters.

In our response, we indicate that we agree that J-13 water may not be appropriate, and cite some additional data that have been made available since our review, since the documentation that the reviewers looked at.

We cited some analyses that we performed on that data, in order to determine whether it's applicable or useful. And we indicate that we're -- we will perform sensitivity analyses on these changes in chemical composition between J-13 water and unsaturated zone water, in order to determine whether it has a significant effect on the results of the code. In which case, we will -- if it does have a significant effect, we will incorporate the changes into the TPA Code, as necessary.

The second sample response that I included deals with our modeling of the thermal pulse from the heat from the repository.

The reviewer indicated that he thought it would be difficult for NRC to justify the assumptions made in those models. And our response indicates that we have done additional research into whether the parameters used for these models are appropriate, especially for the new design that has been laid forth by DOE since the version 3.2 of the code was made by us.

We also indicate that it's not just the abstraction in the TPA Code. That's the only model that we're dealing with here. We do do more detailed process level modeling, and we do do lab research and do experiments, and we ensure that the abstraction, the TPA Code matches very well, the detailed process level modeling, and the experimental results.

So we feel that we can justify the model within the TPA Code, using those more detailed experiments.

So in version 4.0 of the TPA Code, as I said, we had made some changes that already responded to external reviewer concerns. The version 4.0 was in the process of being developed when the review was conducted, so many of the changes that we made with 4.0 had already been decided upon by the time that review was conducted. So therefore, most of these were changes that we were already planning on doing before the review was conducted, and matched up what all with what the experts said, that was important to deal with with the code.

Some of these things that we've done are, we've modified how we treat the parameters that affect the amount of water entry, that enters the drift, that contacts and enters the waste package, so that we can make it time dependent, instead of just having a single constant value. So that we can account for processes such as drift collapse or increase degradation of the waste package through time, to modify those parameters in time.

Another thing that we've done to TPA 4.0, was we incorporated a commercial dose assessment software package into the TPA code directly, so that we can sample the biosphere data, in order to develop our dose conversion factors, rather than just using a single constant mean value. This allows us to assess the variability of these factors more accurately.

Doing that also allowed us to model the build-up of radionuclides in the soil, due to multiple years of irrigation of contaminated water.

We are currently in the development stages of TPA 5.0, and are considering a wide range of changes to the code, in response to the external review group comments, and based on our own judgment of what needs to be done for the next version.

And some of the things that we're considering implementing, based on the -- in response to the comments include modifications to track the chemical composition of water at various locations within the repository system. That a consideration of the effect of year-to-year variations and rainfall on infiltration.

The ability is currently in the code, but we normally leave it shut off when we run the code. We did a sensitivity analysis a while back, stating -- showing that it wasn't too significant on the results. We plan to look back at that, and see whether that still holds true after the changes that we've made to the code, and make a decision on whether we need to reconsider that decision.

We plan on -- we've -- we're considering developing an improved basis for estimates of water, contacting and entering the waste package, possibly with some detailed process level modeling, as in multi-flow.

And we're also discussing whether we want to include redistribution of ash following a volcanic eruption. Following a volcanic eruption, large quantities of ash will be deposited on the side of the mountain, and -- which will be an unstable surface, which eventually will be washed down to the 40-mile wash, which is the direction of the critical group. And we were looking at whether that's going to have a significant effect on results, and if so, we're looking at what we can do to incorporate that effect in the TPA Code.

In summary, the peer review identified many areas of the TPA Code that could be improved, and we've taken these comments very seriously, and have already incorporated some of these suggestions in version 4.0 of the TPA Code.

Additionally, we plan on adding more of these improvements into TPA 5.0, and we believe that the conduct of the external review -- has confidence that the code reasonably models the repository system, that's appropriate for the use in the review of DOE's license application.

And in the back-up slides, you can see the identities of the experts who were selected for the external review, if you're interested.

And that's all I have. Do you have any questions for me?

MR. GARRICK: We'll see. Ray?

MR. WYMER: I have a couple of questions, two actually. The first question is, did you unearth anythings that would surprise you that can't be dealt with if you can't get enough data to future codes, that will be available, the time that you will need to have the code used? Is that a particular thing that -- there's a couple of processes, but anything?

MR. WELDY: Well, one place where the -- we had significant problems in the data is the saturated zone modeling, which is not something that we can really go out and collect. It's really the responsibility of the DOE to go out and collect, and we will continue to incorporate that data, and improve our models in the saturated zone model, as necessary.

A couple of processes we are evaluating; we have a number of -- some groups who have gotten together to evaluate the effects of couple of processes. Primarily, we're looking at thermal, hydrological, mechanical and chemical evolution of the repository. That's a lot of the coupled processes that are important, and we are looking at that, in deciding -- in trying to determine whether it is -- these effects are significant enough, that we need to incorporate them directly into the TPA Code, or whether they're already covered within the conceptual models that we have in there.

MR. WYMER: Was it an enormous amount of --

REPORTER: I can't hear you, I'm sorry.

MR. WYMER: Was a tremendous amount of kinetic data needed to really address the processes adequately, and I don't think that they are necessarily available, it could not be made available in the time -- if it could be available, and that was my concern.

MR. WELDY: Yeah. We're currently using the multi flow coat to do the modeling, to model. And we're trying to match it up to the drift scale test that DOE's continuing. It's running right now and seeing how well the multi flow can reflect the results of that test and calibrating it to those tests.

MR. WYMER: But you don't see any flows -- show stoppers?

MR. WELDY: We haven't -- at this point, we haven't found any show stoppers that would say absolutely we won't be able to use the TPA code in the review of the DOE license application.

MR. WYMER: Second question was, how much -- what parts have you used, if any, of DOE's code? How much have you used what they have done?

MR. WELDY: We certainly track what they have been doing. Obviously, we incorporated the latest design that they have proposed and the TPA Code directly. We don't use any of their models in the TPA Code, but we look at what they tend to see as significant in their code certainly and re-evaluation periodically when we get a new version on a new document from DOE showing what is significant.

We look at our models and make sure that we've modeled the processes appropriately, in order to reflect importance of that process.

MR. WYMER: You don't use their basic structure even?

MR. WELDY: No, the TPA Code was developed completely independent of the DOE Code.

MR. WYMER: That's all I have, thanks.

MR. GARRICK: Milt?

MR. LEVENSON: Yeah, I've got a couple of questions. The first one is were any of your experts, what I would call generalists or systems people, since clearly are the important things that a review should do, is put the pieces together properly, rather than are you a good programmer.

MR. WELDY: Yes. We did have one general, an expert in the overall performance assessment area, that was Dr. Brian Thompson, and he was -- he looked at it at a more global scale, and looked at how we put things together, and how we documented the code, and those sorts of issues.

We also had an expert in FEPS analysis, Dr. Frits Van Dorp, who looked at it to ensure that we had fully and completely done an appropriate FEPS analysis, and incorporated all of the appropriate FEPS within the code.

MR. LEVENSON: I have a couple of specific questions that came from new graph. On new graph A, you identified the basis for selection of radionuclides tracked, was something they commented on.

Was that a rather arbitrary decision made by somebody? You didn't allow the code to reject what was unimportant?

MR. WELDY: How we currently have our FEPS -- have selected the radionuclides that we tracked, is basically the result of an evolution of the code.

We looked at what was important in previous versions in the code, and the radionuclides that were -- we initially tracked a large number of radionuclides, but for confrontational efficiency, we wanted to cut down on that number.

So we looked at what was important in earlier versions of the code. And through that evolution, is how we reached the number of radionuclides that we track at this time.

A lot of their comments were that due to changes in the modeling, that that mix of radionuclides may change, that ones that are important, so you may want to periodically go back and do it, an additional analysis and make sure the ones that you continue to track are still the most important radionuclides.

MR. LEVINSON: On slide 50 in response to the comment of parameters for thermal pulse, did a multi-flow code being used to get liquid fluxes above the drifts, et cetera, I'm not a computer-type, as you probably have gathered already, but did the multi-flow code include gravity? And if not, how do you use it in this case?

MR. WELDY: Yes, the multi-flow does include gravity. Multi-flow is the code developed here at the center, in order to look at these processes specifically.

MR. WYMER: So it does include gravity?

MR. WELDY: It does include gravity.

MR. WYMER: On page 16, you talk about the build-up of nuclids in the soil due to the multiple years of irrigation. Were the assumptions for that the same as used in analyzing whether you or don't get retardation, when the water's running through the same ground?

MR. WELDY: The -- actually, the characteristics of the soil in ermogos evaluate are not the same as the characteristics of the rock within the mountain.

We looked at them separately, to ensure that the data that we used for KD values were appropriate for the -- each location.

MR. WYMER: Is the build up determined experimentally or from analysis and calculations? The context of my question is that, the Israelis have discovered to their surprise, in some of their sandy soils, don't absorb things, and they're now irrigating crops with salt water, because there is no build-up.

Contrary to everybody's feelings. So I wondered whether this could be a fairly important one, whether this build-up is, in fact, based on technical measurements of the actual soil with the actual materials involved.

MR. WELDY: It is actually just based on modeling, and use of some generic data. However, we've looked at the importance of the build-up, and it really doesn't affect the results very much. It's only a few percent for most radionuclides. There's one or two that it's a little more significant, but most of them, it is very insignificant.

MR. WYMER: That's all I have, John.

MR. GARRICK: George?

MR. HORNBERGER: The -- I just have a couple of questions on your action plan for responding. I think that the examples that you cited, it's clear that you can move forward with a lot of the comments.

It strikes me that there are some that may be a little different from your examples, however. The one you used as an example in your response to raised question, that Demorceli (phon.) said well, we simply don't know how water flows in the saturated zone. That's not a comment on your TPA code. That's a comment on the availability of constraints through the -- that bound the calculation, in any sensible way.

How do you plan to -- and there are other comments from your reviewers that I would put in the same category. That's not the only one. How do you plan to put that into your action plan for responding?

MR. WELDY: The main plan with comments such as that, that really involved data collection are to pass them on to the DOE, and make sure the DOE has sufficient data to support their models. If the DOE has more data that's available, then as that data becomes available, we'll incorporate it in the DOE code to make any changes to the models there, that are necessary.

MR. HORNBERGER: Does that -- I guess what I'm trying to get to, does -- do you agree with the assessment of all of your reviewers that these are critical that are missing, and that DOE absolutely has to provide these, or they won't be doing their job?

MR. WELDY: I don't think I can answer that broad of technical areas. I think there's certainly some filtration that goes through our technical experts' minds, based on analyses that they've done, sensitivity studies, as to whether the data is absolutely critical, or whether it could only change the results a little bit. So it's not really as necessary.

MR. HORNBERGER: There are perhaps fewer cases of this. You've responded about a couple of processes. But things that may relate specifically to the structure of your TPA Code and whether you could answer some of these things.

The one that comes to my mind is the comment on the potential importance of lateral flow diversions in the unsaturated zone when you're using the one dimensional vertical model. How do you respond to something like that in your action plan?

MR. WELDY: That one hasn't been responded to yet. I'm not sure how we're going to respond to that. I believe that we'll conduct some sensitivity studies. Maybe look at some of the DOE results where they have the three dimensional code, and see how that affects their results. And do a comparison between the two to make an assessment as to whether that process is important under the results of the code.

MR. GARRICK: One of the suggestions had to do with the lack of data that George was just referring to. The lack of data for the saturated soil modeling.

My earth scientist, Collie Zavalos (phon.) impressed with the fact that the greatest unknown in this whole process is how to do detailed modeling in the unsaturated zone.

So I was a little surprised to see, and that modeling is kind of old hat in the saturated zone. So I was a little surprised to not see something on here about the unsaturated zone, as far as modeling of rainfall into the -- and infiltrating into the near field.

MR. WELDY: We actually got a very limited number of comments on our modeling of the infiltration within the mountain.

MR. GARRICK: Uh-huh.

MR. WELDY: I assume that means that we've done a pretty good job.

MR. GARRICK: Yeah. Well, that's encouraging. As I say, I've been led to believe that where the analytical models is weakest is in how to model ground water movement if -- of an unsaturated zone. So that's kind of encouraging.

MR. WELDY: Yeah. One thing is, we don't give a -- within a TPA Code, we don't give a lot of performance from the outside unsaturated zone, due to fracture flow through a lot of the --

MR. GARRICK: So --

MR. WELDY: -- zones.

MR. GARRICK: -- it's pretty much a matter of just the rainfall?

MR. WELDY: Right. The amount of rainfall to contend, and we really didn't receive many. There was one comment on that the thermal effects causing fractures in surface might could increase your infiltration. There are one or two other comments, but there wasn't anything too significant.

MR. GARRICK: The only other comment I'll make at this time, and maybe this one should come up later, is the comment having to do with insufficient modeling of chemical composition of water. I'm not surprised to see that there.

If I were asked to, on the basis of my reactors' friends, how I would model this, I would model it the way we discussed here a couple of years ago, of creating an infiltration model that had output states that basically become the input states to the near field.

And those output states would, in this case, be water composition of different types of water, if you wish. And that would be a way to build in to the model explicitly the ability to consider all the evidence that would support one water composition versus another, because you could basically assign likelihood values to each of the different water states.

Now, have you considered doing anything like that?

MR. WELDY: I know that our technical experts are giving it a lot of consideration, and they're doing a lot more of looking at how we can incorporate that into the TPA Code.

I'm not sure which way -- how they're going to decide to actually incorporate that.

MR. GARRICK: It just seems to be a rather straight-forward approach, and would enable you to incorporate into the model, the different water compositions, as well as your full state of knowledge about which funds you referred, and what the supporting evidence is for that, and to characterize it with some sort of a probability distribution curve.

MR. WELDY: Uh-huh.

MR. GARRICK: It's an opportunity for some real nice modeling that addresses a fundamental question that's been around for a long time.

MR. WELDY: Uh-huh. Lora Browning, and she could probably assess that a little bit better.

MR. MCCARTIN: Yeah, I'll address it in a subsequent talk.

MR. WELDY: Okay.

MR. HORNBERGER: And your earth sciences colleagues thank you for taking the time to -- chemistry on that unsaturated zone, such as straight forward --

MR. LEVENSON: I've figured out a way to do without the --

MR. GARRICK: Algebra. I have one more question. I think, and the reason I think is because we received a little over six inches of paper for this meeting, so I'm not sure what I read where, but I think one of the peer review comments addressed a matter of conservation of mass not being your code. Is that correct, and if so, what's your response to that?

MR. WELDY: We're looking into that. Whether we have full concentration of mass within the code. I'm not sure off hand if we explicitly tracked that. Tim, do you know?

MR. MCCARTIN: I'd be amazed if it isn't concerned.

MR. HORNBERGER: And you did that comment?

MR. MCCARTIN: Yeah, we did get a comment. I think -- my understanding is, it was related to oh, I think some of the disruptive events, where we don't account for, say, when volcanizism occurs, we assume X. We just accounted for the decrease in inventory from disillusion. I'd have to go back and check for sure.

And in that sense, I will say, yes, we do not conserve mass.

MR. HORNBERGER: All right. We may double count that in inventory in that stuff that's removed by the volcanic event might not -- but still remain in the river.

MR. LEVENSON: The context for the question, I don't know if peer review if a context, but my context was, a couple of years ago, when I was involved with the DOE Code, we discovered that, in fact, they didn't have conservation of mass, so that from a one curie source term a hundred years later, you could have one curie per cubic feet or soil out 20 miles. So conservation of mass is incredibly important.

MR. MCCARTIN: And in that regard, with respect to the brown water pathway, when stuff leaves from the source, mass is concerned.

MR. LEVENSON: I wasn't asking about this second order.

MR. GARRICK: Jim?

MR. CLARK: I have just a couple of questions, kind of in the general heading of background. You're writing an independent model from DOE's?

MR. WELDY: Yes.

MR. CLARK: They're different, they're about the same. If you just look at the subsurface, yours is one dimensional, isn't it?

MR. WELDY: Unsaturated zone modeling is --

MR. CLARK: Okay. Okay. So you're doing -- you're looking at major confusion and saturated zone absorption?

MR. WELDY: We are looking at absorption, we are looking at main distribution, yes.

MR. CLARK: Okay. Now, you don't generate any data, so the data that you need for your model comes from the DOE; is that correct?

MR. WELDY: The DOE is technical literature. Certainly the -- all the unsaturated zone data has come from DOE reports. We certainly screen it, and determine whether we believe that it was requested appropriately before we --

MR. CLARK: Are you -- their data gathering effort is going to give you all the data you need, since they're different models.

MR. WELDY: Where there's not DOE data available in an area, we generally will use data in the technical literature. If it's not available in either place, then we need to look at that and see how we're going to -- how we can come up with values for those processes.

MR. CLARK: Because, you know, you can get into trouble using data developed specifically for one model and another model.

MR. WELDY: Uh-huh.

MR. CLARK: If you -- do you know, what's the process? What happens when you get results and then get results and you get together and compare them and --

MR. WELDY: Yeah. We --

MR. CLARK: How does this work?

MR. WELDY: We have periodic technical exchanges where they'll discuss the results from their code and we'll discuss the results from my code, and we'll do a comparison of what we -- our different codes show, or are the important processes.

We compare results, the different individual sub-modules and see how similar they are or how different they are and have discussions and discuss why they're different.

MR. CLARK: And so far, you're comfortable with this process at least --

MR. WELDY: I think it's working very well. I think it improves both of the codes to have these sorts of exchanges, because both staffs could --

MR. CLARK: The meeting with the experts was your meeting. That was something you did.

MR. WELDY: Right.

MR. CLARK: I assume the responses were generated by your folks and they were in the meetings where the experts were discussing, so there was good communication on your side. How does this get communicated to the DOE? What came out of it?

MR. WELDY: We'll certainly discuss any results that we have at the technical exchanges, any weaknesses the experts identified in our code, we'll look at their code and see what their -- they might have a similar --

MR. CLARK: Okay. So it's not being done through KTI's as John asked, but there is a mechanism of working groups.

MR. WELDY: To transfer the data?

MR. CLARK: Yeah.

MR. WELDY: The members of the --

MR. CLARK: That's where it concerns.

MR. WELDY: Okay. The members of the ISI's are also members of KTI's, that's the way our organizational structure is right now. Is it would've been KTI's, so there's a lot of crosstalk between the ISI's and KTI's.

MR. CLARK: And I appreciate the concerns about your code, which may or may not -- concerns about what they're doing, but there is a mechanism to have that communication.

MR. WELDY: Yes, there is that communication.

MR. GARRICK: I might point out that one of the KTI's is total system performance.

MR. CLARK: Do you think your -- well, do you think your approach is more conservative, given the differences in the models, since you have a one-dimensional model?

MR. WELDY: It varies. Actually, there are some areas that were more conservative at EON. There's some areas that DOE is more conservative than we are right now. We attempt to do the bodily best we can. We don't attempt to be overly conservative, by any means. We have to be as realistic as we can in our modeling.

And if the DOE feels that they don't have the data or the information support, our models, like ours, based on that are even a more conservative model.

MR. CLARK: But in the unsaturated zone, you stated -- your deep peculation is shown in -- there are no loss mechanisms along the lines.

MR. WELDY: Yes. We assume uniform flow from the shuttle service to the deep peculation. Looking at the DOE's three-dimensional model, we looked at that, and there's very little difference between their shell on completion and deperculation values. So we felt that that somewhat justified our approach.

MR. CLARK: Thank you.

MR. GARRICK: Dr. Ewing.

DR. EWING: Just by way of -- background for myself and others may have the answer. Did you contrast the two codes, the NRC code and DOE code, in terms of general size, number of input, parameters, percentage of use of expert opinion, for the input of granditures, one dimensional versus three-dimensional, number of sub-routines or sub-models?

MR. WELDY: We haven't done a formal comparison like that. Tim, do you want to --

MR. MCCARTIN: Yeah. I guess part of that I'll be talking about later and the use of the Code, and -- but I don't know if -- we are trying to directly compare the two.

Our code is a tool for us to help us review what DOE's doing. And so in a way, we use it to inform our process. We use it to get insights to then query and probe the DOE analyses.

So in some respect, there is a comparent contrast, in that, we might see something in R CO G or very sensitive to say, temperature or release rates. Maybe the DOE Code, they're not seeing that type of sensitivity. We would want to understand why. What are they doing.

But it really is a review tool, and we are trying to say, we have the right approach.

DR. EWING: I guess what I'm asking, I'm asking several things, but from your answers, I've expressed some concern about the process of licensing the -- being of one comparing one code to another. And the discussion is, both your answer is different because yours is one dimensional, or your expert opinions are different, or you used a different chemical base.

The real issue is, do the codes represent, in some sense, the performance of the site. Not do the codes give the same range of answers.

MR. MCCARTIN: Absolutely. It's not the comparison, does our code sort of match theirs, in any sense. It is really what is the DOE's result and what's the basis for their results.

Now, we use our code to assist us in probing DOE's analysis, in terms of what's important to performance, what kind of results they're getting. But it really doesn't fall upon our code and the results of our code. It's really what DOE's getting, our understanding of what DOE's getting, and the technical basis they have supporting their results.

DR. EWING: Let me ask the question in a different way. The comparison can be very useful as an example, if you compare different ways of batching your sub-models. I mean, it could break your -- the DOE Code might be very detailed and have a sub-routine for corrosion of glass, a sub-routine for the air fuelogy of chemistry.

Or you could batch them in a simple way, or in a complex way, but in different combinations. It would be interesting to see the answer to the same.

So does that happen? Are you so different that you see the different batchings of the sub --

MR. MCCARTIN: We -- there's no question in some areas we have very different approaches than the DOE. Some places we're similar. There's all kinds of different kinds of combinations, and you're right. I mean, it is useful to see when DOE does some of their sensitivity analyses, all kinds of results they get, based upon different concepts of approaches.

We do it different. We (inaudible), and we use a different conceptual model, are they that different, why are they that different, why -- or in terms of intermediate results, are they the same.

There's a lot of -- you're right, there's a lot of different combinations of looking at the system, and abstracting different processes. And between the two groups, I think there's a fairly broad spectrum. And I think that's one of the purposes of the NRC Code.

We probably have, if I had to guess, if I broadly would state, that we probably have more combinations of things to look at than DOE does, because we're interested in a lot of different things of what could go wrong.

DR. EWING: And one last question. In terms of the usefulness or I don't want to say usefulness, of the TPA Code, do you test it against natural analog data?

MR. MCCARTIN: To the extent that we can, we have used some analog data. One of our --

DR. EWING: is that a large extent, small extent or --

MR. MCCARTIN: To date probably the -- I'll point to two examples. One would be the Pena Blanca natural analog we use for release rates for source term is one that we try to extract some information from.

The other would be, I would maintain Chlorine 36 and Yucca Mountain gives some evidence that there are relatively short travel times in the unsaturated zones.

DR. EWING: Thanks. You use Pena Blanca in your example as an input into your code.

MR. MCCARTIN: Right.

DR. EWING: I'm asking, did you try to model something and then you (inaudible) using it.

MR. MCCARTIN: The fusion.

MR. GARRICK: Andy?

MR. CAMPBELL: Do you guys have a copy of DOE's Code? Have you kind of picked it apart and taken it apart, looked under the hood and see how it works, or are you getting this from a far?

MR. WELDY: We don't yet have a copy of DOE's Code, but we're currently working on acquiring a copy, hopefully prior to the release of SR, so we can do a little of that probing, as we're doing our review of SR.

At this point, I don't believe we have a copy of the Code yet.

MR. ESH: Yeah, that's right. This is David Esh. We're working on getting that.

REPORTER: I'm sorry, what's your name?

MR. ESH: David Esh. We're working on getting that, and we should have the Goates (phon.) in, you know, Goates and Cook Code very shortly, then we have to get all of the dynamic link libraries and the other stuff that goes with it from DOE.

But our goal is to have it before the SR, and that start -- and this discussion of we tear our code apart, and I'm going to talk about that some. We expect DOE to tear theirs apart, and understands how it's working, and we have plans to get theirs, too. And to evaluate to the extent that we can.

So all three of those things are a part of our review.

MR. CAMPBELL: How long a process do you anticipate that to be? Because that could get to be a fairly lengthy and involved process of getting into the guts of the code and everything else.

MR. ESH: I think the answer is, we'll do what we can with the resources that we have, and the time that we have. We'll do your best -- we'll do our best, that's all we can say.

MR. CAMPBELL: The political escape.

MR. GARRICK: Okay. Any other questions from the staff?

All right. Tim, we've already warmed you up a bit.

MR. MCCARTIN: James answered them, so it should go easy.

MR. HORNBERGER: You've already done half of your presentation.

MC. MCCARTIN: Yeah, exactly.

Okay. Up to this morning, for the rest of the part of the presentation, I'll give a status of the NRC performed assessment code clearly in the time allotted. I am not going to go into great detail on the code.

I'm going to give a quick overview of the key things, and I would say that I'll try to go quickly. There are people here and in Rockville, that while the committee and consultants in their particular areas, to go into more detail, feel free to ask the question.

Generally, I'll talk briefly about the roles of the performance assessment code, key aspects for estimating performance, which will be those areas. Then I'll then go into the status and there's some bias, in terms, I had to pick what parts were key. I selected among the ones that -- which ones I determined to be appropriate in terms of fascinating performance at this time.

I'll talk briefly about gaining confidence in the performance assessment.

In terms of the rules of the performance assessment code.

Generally, we're going to use TPA to review DOE's performance assessment. In the MZTPA, there's a couple of areas, we'll certainly risk inform our review process. We want to probe at DOE's analysis, where we think the most important impact, the largest effect on assumptions, where there's uncertainties, et cetera, there's three categories in this particular --

MR. GARRICK: You changed that for your live show, the whole page will come up.

REPORTER: It's in Word Perfect, can you --

MR. MCCARTIN: Go to view page and reduce the mag -- the percentage magnification.

MR. GARRICK: A full page. There you go.

MR. MCCARTIN: Of the three bullets, I think there's two aspects there that I'd like to at least talk about.

My subsequent talk later in the day, actually gets into more detail, but one in terms of evaluation of overall performance.

We can certainly do some side calculations to get a sense of the waste package lifetime, do some calculations on the brown water pathway, look at retardations. But there really isn't any substitute for doing a side calculation on what the dose is going to be.

We used the overall performance assessment to do that. It's a way to integrate all our understanding of the site. That also includes both the uncertainty and availability of the site. What we don't know, as well as what we know, but that's the one benefit of a TPA Code, is you have no substitute for, well, what should the dose be.

You have all these separate modules that, all in their own way, affect that final dose. You need to integrate it some way. And that's one of the advantages of a performance assessment.

Then, with that result, we can look at the sensitivity and uncertainty, with respect to what's driving the result, looking at the parameters, assumptions, conceptual models, in terms of both overall performance. And you'll see with our code, as you know, we have many, many different intermediate outputs, so we can look at the sub-system performance.

And finally, hypothesis testing. One of the things that we've tried to do with our code is include a number of features that we can test different concepts, be it the release rates, be it the transport in the unsaturated zone, saturated zone, all kinds of things can be tested doing the what if calculations. That's also very important.

You'll see some of these types of analyses and ability as Dave Esh purported to tear apart the model in the subsequent presentations.

In terms of the key aspects, we're estimating performance. First, deep percolation. How much water is getting down to the repository level. Near field conditions; what is the temperature, water chemistry, how much water is getting to the waste package.

Degradation of the waste package, radionuclide release rates, transporting the unsaturated zone, the saturated zone, and finally, the exposure scenario.

I'll talk to each one of these, in terms of our approach in the TPA Code, what's included, what isn't included, in a very broad sense, and what our plans are for potential improvements to the code.

First, deep percolation. I know one of the interests of the committee has been what kind of coupled processes, and I'll try to give a sense of what kind of interactions we have within the code, what kind of correlations, climate variation, certainly precipitation and temperature are very important to what the shell infiltration rate is.

We have both rows in the code. There's surface features, the elevation, the thickness of the soil, evaporation at the surface all contribute to what the shallow infiltration is going to be.

Next, obviously the site is very heterogenous at the surface. There's facial variation. We do account, in a limited sense, on that facial variation, we do averaging over what we call sub-areas. We break the repository into specific units.

It's primarily for efficiency purposes. We're not going to simulate say, a very complex three dimensional grid, but we do face it in sub-areas when we represent the repository, it's infiltration, it's temperature for a particular sub-area.

Right now, I think -- at one time, we had seven. I think we're at ten now. It varies a little bit that and those sub-areas vary depending on the characteristics of the unsaturated zone and portable aspects of the repository design.

And then there's a thermal reflux. We certainly have to account for the thermal reflux. Right now, that is primarily a temperature dependent process that we use, a conduction only model for the mountain scale, thermal temperature model.

The -- that particular one, we're not accounting for the interaction between the temperature and fluid flow, where we're looking at just conduction only.

There are the multi-flow code is used to provide some additional parameters, in terms of how much reflux we would expect to see and there is some parameters that account for that, that are derived from multi-flow. But right now, the temperature aspect, where the boiling isotherm is based on a conduction only model.

In terms of what processes aren't included in the deep percolation. Surface run-off and plant transpiration, there is a pre-processor to our infiltration that does try to consider the effects of run-off and transpiration, but there isn't a very explicit model for run-off and plant transpiration.

Non-vertical flow, as was brought up. Is there some diversion that interfaces between layers above the repository that would account for less infiltration in some areas versus more infiltration than in other areas, that's not accounted for.

And as I said, the explicit coupling of temperature and fluid flow, it's -- we do some off-line calculations in multi-flow to give us some sense of the reflux, but there is an explicit modeling of fluid flow and temperature within the code.

Right now, in terms of improvements, we don't see any. However, you know, I would say, we clearly, as you'll see, we're doing a lot of simulations with respect to the non-isothermal conditions, and we certainly could change some of the parameters within the code to simulate different types of reflux conditions. But we aren't anticipating any model changes. We'll still stick with the particular conduction only model, and trying to represent reflux in a -- in this way, where we've abstracted for multi-flow.

MR. GARRICK: Tim, is there deep percolation or recharge anywhere except underneath the mountain? That is, I'm thinking about the connection to your saturated zone model?

MR. MCCARTIN: No, there's -- there are -- yeah. There's no --

MR. GARRICK: The only input of water is from the mountain?

MR. MCCARTIN: Right, yeah. There's no connection between the recharge and the saturated zone flow.

Near field conditions, heat transport is modeled in three scales; the mountain scale, the drift scale, and the waste package scale to meet the temperature at the waste package for porrosion. We need the temperature and the spent fuel for dissolution rates. The relative humidity is dependent on temperature.

Now, the effects of coupling of water chemistry and flow and temperature is considered using specified conditions. We will take -- right now, we'll have the fluoride concentration is represented from a file that's input from multi-flow. Multi-flow does a calculation to see what the temperature -- what the fluoride concentrate is, say at the drift wall.

We then have a multiplication factor to account for, well, what would the chloride concentration be on the waste package surface. It's a strict multiplier.

So there isn't this explicit coupling of the water chemistry and the fluid flow, but we do have this external file, and we do try to account for any increase in chloride concentration. Currently, we believe that's one of the more serious conditions for modeling the corrosion of the waste package.

Things not included. Like I said, we don't have explicit coupling of the water chemistry flow and temperature. We don't have the effect of precipitation on fluid flow during the thermal phase.

What if precipitation nears to drip (phon.) occurs and precludes infiltration from coming in to the direct. That's not accounted for.

Evaporative losses from -- of the thermal output, and in that sense, the chemistry that -- like I said, we have that multiplier, but there isn't an explicit consideration of evaporation, where we just have a straight multiplier, and just assume that the chloride concentration is increased.

Planned improvements. Obviously, we -- you heard yesterday some of the things with the waste package, there could be some trace elements that could cause problems for the waste package.

Some of these chemistries we're looking into, we think we'll be able to include other types of chemistries into the TPA Code. But once again, there wouldn't be this explicit coupling, but what we're trying to do is, let's do some detailed modeling, let's look at the problem, what are the kinds of conditions that we think are going to cause problems to the waste package. Include that condition into the code as an option to model it this way.

And that's sort of what I'm talking about, to explicitly model all the things that would go on, would take a massive code. But we can be very smart in what we choose to pull in, and like I said, the multi-flow code is one code. Some of the experiments have done on the waste package.

What kind of chemistry should we be worried about. Let's get those effects into the code. Although, it won't be directly tied to the flow per chance, but the effect of increasing corrosion rates, we can get that in. And I think that's how we'll deal with these -- the water chemistry per se.

Degradation of the waste package. Right now, our corrosion is dependent upon humidity, temperature and chloride concentration. Obviously, you saw the previous life, why we have chloride concentration in the near field. We have mechanical disruption, the rock fall, fault movement. We have the drip shield.

The drip shield is included in our code, and currently fairly simplistically, we do all flying modeling in the sense of when the drip shield will fail. Can be sampled, and so we have a failure time for the drip shield.

When the drip shield isn't intact, the chloride concentration on the surface of the waste package is not increased. That chloride multi -- chloride concentration multiplication factor is not used.

We also have juvenile failures. Processes not included, once again, this explicit coupling of water chemistry, flow, and temperature is not included.

Also, one of the things that we've thought about, we don't think it's that important; however, we continue to look at it, and are aware of it, and that would be the effect of mechanical disruption on the corrosion process.

Some rocks fall off the ceiling of the drift, they hit the waste package, dent it, do some damage; does that increase the corrosion at that particular point of impact. Right now, we don't think that's important, that's why it's not in there. But certainly, it's one of those things you want to be aware of, that you're not considering, that could affect corrosion rates.

Planned improvements. Once again, we think we need to include some additional water chemistries to account for potential trace materials that could increase the corrosion rates.

Two things though, the last two things for planned improvements I probably should have put them up. Also under processes currently not included, and I didn't want to put it in both places, probably should have, but one is we'd like to include stress corrosion cracking, which is currently not in the code, and consideration of weld and crevice corrosion, also in the code, that currently is not there.

Radionuclide release rates. Obviously, there's a -- once again, you get inside the waste package. There's a lot of things that can go on.

Currently, we have four different release models that we can -- in the code, that are dependent on temperature of water chemistry. We aren't explicitly coupling the water chemistry in all these four release models. But what it is, it once again, somewhat like the waste package, you have a particular condition that you're worried about, or you want to represent or include what the release rate is. For example, sume silicon and calcium and the bions in the water, et cetera.

So we're -- account for specific conditions, and look at how that affects the release rate. We have two waste package degradation modes, the back-up and the flow through. Solubility limits, gap fraction and the seepage is coupled to the thermal reflux.

When we look at -- the release rate is dependent on how much water is getting into the waste package. It is coupled to the thermal reflux.

One thing I would like to say, item number four, the gap fraction, I think is a very important aspect of the way we model the system, and iodine and technesium both have gap fractions.

Iodine is pretty high. I believe it's six percent. It's instantly available for release. That means, once the waste package fails, six percent of the iodine inventory is available for release.

When you look at how bad things could be, clearly, having six percent of the inventory instantly available, it can't get much worse than that. It's a fairly rapid release rate, and a significant amount of the gap fraction or of the overall inventory of iodine and I think we're -- we've looked at those percentages. I think that's an important parameter.

In terms of processes not included in the code, we don't have explicit inclusion of the water chemistry inside the waste package. As I said, we have some particular water chemistries we're accounting for, in terms of the release rates. But we aren't modeling this -- the coupled processes of what's going on inside.

The thermal affects on seepage, once again, in terms of precipitation, if the -- if precipitation during the thermal period of certain minerals and fractures and in the matrix that shut off water into the drift, we aren't accounting for that.

The affect of drift collapse on seepage, we are accounting for that. Obviously we do try to account for some diversion at the water at the drift, but as the drift collapses over time, and rather than a smooth surface, it's a more jagged surface, there could be a larger perpensity for drips to occur, where rocks have fallen off, we look out for that.

And we take no explicit consideration of coil release. There are ways, as the developers of the code, we can trick the code into simulating common and release, but we don't explicitly consider that.

In terms of planned improvements, once again, I think we tried to include -- look at including at additional water chemistries, as we do more modeling. We see more data from the DOE, in terms of what are the things that are going to cause problems, increase release rates. We'd like to include different chemistries to account for that.

Glass waste form. Right now we have just spent fuel. We'd like to explicitly consider a blast waste form, and coil release, we think we can include in the code.

The unsaturated zone, obviously the fracture versus matrix flow is important, we account for that. Retardation, we also account for; although, right now, when we run our code, we aren't accounting for retardation in the fractures. And matrix diffusion, we have the capabilities, but we rarely use it. Based upon our rather rapid travel times in the unsaturated zone. It doesn't do a lot, and it computationally takes up a lot of computer time. So to date, we really haven't used it significantly.

Processes not included. We don't include any thermal effects on flow below the repository. Whatever our deep proferlation rate is, we get some average rate, and we use that for each of the sub-areas.

Diversion at layer interfaces, we have not accounted for. Although, one could look at it, if you had some 3-D models that showed, in particular, regions of the repository, that there was diversion of flow.

Say, you got to a particular layer, you went horizontally for a while, and then went downwards somewhere else, there's no reason NEFTRAN can't handle that. In fact, NEFTRAN, the code we use for flow and transport has been called a quasi 2-D model. It's a pipe model. You can make your pipes go anywhere you want.

So there's no reason we can't include that. To date, we have assumed predominantly -- well,

MR. GARRICK: Tim, why do you use the average rates, when you could use some sort of distribution of rates?

MR. MCCARTIN: Well, average in the sense for each sub area, there's an average. And it is time dependent. But we are explicitly -- we take a -- we do it on a sub-area basis. To not do it that way, part of the problem gets to just a mere computation problem.

MR. GARRICK: Of course, if the sub-areas are small enough, that's okay.

MR. MCCARTIN: Right. You can certainly shrink the sub-areas down, if one wants to, but --

MR. GARRICK: Yeah, okay.

MR. MCCARTIN: And then disruptive events, we aren't including the effect of disruptive events on flow, seismicity faulting, one could imagine, could cause some pertivations to the flow system, that's not included.

Planned improvements. We're looking at including the dependence of Kd's on the water chemistry and once again, adding colloid transport.

Saturated zone transport. Some of the same things, fracture versus matrix flow. In the top, we're assuming fracture flow. In the alluvium matrix flow, retardation is primarily the alluvium and in the matrix portion of the fractured path and -- we do account for matrix diffusion in the saturated zone.

Variability in the flow path is considered. We can make the extent of the alluvium, as little or as much as we'd like, and that's where, in terms of the peer review, they weren't happy with the support we had for the -- our depiction of the saturated zone, but we feel with the code, we can account for very short travel times, all in fractured tuff, or slower transporting alluvium.

So we somewhat have the water front covered, in terms of what can happen.

What exactly is the case that really is -- DOE will need to come in and support that, but our code has the capability to analyze the impact. And once again, that's what we're trying to get with our code capability. We -- the onis on DOE to come in with a licensed application that provides performance assessment and they can defend. We need to analyze the -- and review what they've done.

Planned improvements. Once again, we'll do the Kd's on water chemistry, and add colloid transport.

Finally, exposure pathways. In the code, we have variability in the wellhead dilution, basically the volume of water that's pumped by the receptor group.

We have variability in the diet of the receptor group, something we didn't have before, but we can account for a range of different diets.

The irrigation for the locally produced crops is coupled to precipitation. Obviously, as rainfall increases, the amount of irrigation drops a little bit. It isn't that significant in this particular environment.

We did couple it. It's one of those things you put in, trying to see if it is a big effect.

Processes not included. The volcanic disruption only considers the air pathway. When that occurs, obviously, there's radioactive ash spread out over a significant surface area. That water rainfall will eventually go in there at leach radionuclides, eventually to the water table. There could be some doses, due to ground water. That's not included in the exposure pathway. We were just counting on the air pathway that it -- it's relatively -- fairly large. We think it isn't a big contributor, but it is not included.

We aren't looking at variability between individual wells. Clearly, we have a receptor group that one well isn't producing all the water means. There's a variety of wells, concentrations, just heterojavium (phon.) the area. The concentrations would be higher at one well, lower in another. We think in terms of assuming all the locally produced food is contaminated on average, gets us a reasonable number, but we do not account for that spacial variability in the plume. We do, as you know, assume that the entire plume is intercepted by the receptor group at 20 kilometers.

The question is, okay, that in a very short nutshell was the -- some of the key aspects of the code. How do we gain some confidence in performance assessment, and I think there's three aspects to what we do.

Certainly, we're going to use the data and observations that are out there to compare it to. Be it laboratory field experiments, physical mathlaw (phon.) analogs, to the best, to the extent we can.

We also use, I think the analytical approaches and methods that we have as Dave Esh, tearing apart the code, we have done over the years extensive evaluation of the sensitivities, what matters, what doesn't matters -- doesn't matters -- that's not English.

But the -- not only looking at the final result, but the intermediate results, and the basis for those intermediate results. And I think it's very important. We've done -- and it's just not the parameter sensitivity, looking at different conceptual models. And we have a variety of ways to include different concepts into the TPA Code.

In addition to, we have an importance analysis, where we can pending grade, particular barriers, see what the results are. I think all of that is part of that process of understanding the code. That clearly is at the heart of what we need to do.

Doing this work, I think helps us in looking at DOE's results. We need to understand their code, why did they get the results they did, and what does it mean.

There's certainly administrative controls that we have. The Center has a configuration management system, Top 18, the software and development and the inputs, I think we keep a pretty good control of what we've done, how we've changed it over the years, what was the basis for the parameter selection, et cetera. And I think that's all important.

And I would like to -- my next line is -- and I know the committee has been interested in it, I think were interested in it; how do you explain the results of this

PA to other people?

When we talk amongst ourselves inside our little cubicles at NRC, we're in up to our elbows into the code, we don't necessarily require a lot of discussion as to what's being done, because we sort of know it.

When we go out to talk to the public, talk to a licensing board potentially, commissioner's assistants, how do you explain the code. Why will people have confidence in your results.

I think one of the keys is evaluation of the subsystem performance, and I'll look at the influence of seepage. What does it really mean? I think I'll look at my code results.

How many waste packages get wet? When do they get wet? How much water gets into the waste package. I can explain that to people and show what our codes doing, different concepts, how it will affect that particular aspect.

The low rainfall, everyone's going to have a good sense, gee, we get around six inches of rain here, but walk through that, right now, for our code, the way we run it, not seeing it's right, but on average, we have 50 percent of the waste packages getting wet.

I think you can tell that to someone, well, okay, it can't get much worse, two times higher and it's all of them getting wet. And there's several things like that that you can explain what it matters, and especially for radionuclides like iodine, where it isn't dependent on that much water, it's more how many packages get wet.

Because as I said, the gap release releases six percent instantaneously. It isn't terribly solubility limited, so you can get a sense of why the results come off the way they do, what should I be worried about.

Going back to waste package degradation. We will have a failure time for the waste package. Be it 5,000 years, 50,000 years, 500,000 years, whatever it is, you can tell people the failure time is X. You better have some understanding of the uncertainties and the basis for that.

But people will understand the failure time and certainly you have to count for the juvenile failures. Things that, yeah, you intended to build it this way, the properties weren't to be this way, but it just didn't work out that way. And as you know, with our code on average, I believe we have 35, 36 failed containers from the beginning from T0.

Release of radionuclides. Once again, if you have retardation, such that iodine technesium are the primary nuclides getting out in the first 10,000 years. Once again, we can look at the gap fraction, driving six percent instantly in one year, how much worse can it be.

And I think there's things like that, that you can explain that will give people a sense why the results came up the way they did, how much worse could it be, which is what I think the public will be interested in. What have you accounted for, what have you not accounted for, et cetera. And then finally, transport in the unsaturated and saturated zones.

You'll certainly have some idea, well, how long did it take you. Again, from the repository to my critical group, for retarded radionuclides, it's going to be than 10,000 years. What is the reason you didn't see those there, you better have a basis for the retardation values.

If it's alluvium, how much alluvium, what experiments have you done to look at the retardation mechanisms. For other things, once again, iodine technesium, to a limited extent, petitium that aren't that retarded.

Right now, for our code, based on -- merely upon chlorine 36, we think there's certain some portion of the flow system is fairly rapid. There's very little hold-up in the unsaturated zone. There are a few subareas that have significant thickness of Calco Hills venture (phon.), where it's primarily matrix flow, and that is --

that has a significant tie. It does delay things.

Then the saturated zone. There's certainly -- you can give people a sense of -- it's not going to be instantaneous. We're at 20 kilometers. It's not going to go from Yucca Mountain to 20 kilometers downgradiant in one year. Is a hundred years the right number? A thousand?

But once again, you get a travel time. What's your basis for it, et cetera. And I think as you walk through, and I've thought about -- been thinking about a way to explain that in approximately 30 to 45 minutes in a very simple way, what the results of the code are, what are the uncertainties, and how bad do we think it could be. And just explain that in very simple terms, in travel times, release rates, waste package lifetime, and the number of packages of whatever filtration that I think would give people a sense of why the numbers came up.

But understanding all those things, the basis for them, et cetera, I think is how you ultimately will provide a sense that indeed, the performance assessment is giving you numbers that you have an understanding of what's going on.

And in summary, I think the TPA Code gives us an independent approach to review DOE's performance assessment, looking at a lot of different things.

We certainly expect to selectively probe the DOE analyses, part of the risk informed aspect or certain things that affect performance far more than other things, and we'll certainly use the code results to help us there. And I would maintain the confidence in the performance estimates is obtained in a variety of ways.

And with that -- I went longer than I expected, but I'll certainly be happy to answer questions.

MR. GARRICK: Thank you, Tim. We do have a real challenge here. We have a tremendous number of things on the agenda. We want to get through all of them, and unfortunately, we're not going to have the opportunity to discuss each of them to the level that maybe some of us would like, but we're do our best.

We'll allow a few questions now and then take a break. George, do you want to start off this time?

MR. HORNBERGER: I'll pass.

MR. GARRICK: I didn't mean to -- Milton?

MR. LEVENSON: Yeah, I have one. One of the disadvantages is most of what we know is what people tell us.

There are -- a couple of meetings ago, one of the slides showed that the Navy field was not going to be buried in C-22 canisters, but in stainless steel canisters. Have you looked at that at all?

MR. MCCARTIN: I thought the Navy field, and I could be wrong on this, I thought it was going to be inserted into a similar container.

MR. LEVENSON: That's my premise, but I --

MR. MCCARTIN: I'm seeing nods shaking, yes, so I -- yeah.

MR. LEVENSON: Okay.

MR. WYMER: Well, I'm not going to be intimidated, John. A couple of --

First, let me say your presentation was excellent. I thought it was very --

I'm a little bit disturbed that the effect of the in drift materials and chemistry has not been directly fully addressed, particularly you mentioned calcium and silicon, for example, being in the water. But as you know, I'm sure, you will have a possibility of all kinds of soluble formations, you'll have absorption on oxidized iron, things like this and level of read-outs potentially because of the materials in there, like the titanium. Titanium 3 is a very strong reducing agent.

So that's not a question, that's just an observation. It seems to me that's an area for improvement.

MR. MCCARTIN: Absolutely, I agree. I mean, I can't -- the code doesn't have it, so I can't blame that it does. But I think we have recognized that -- and we're in a constant source of development, and that's one of the areas that we're looking at. But it's a fairly complex problem. What is the right kind of chemistry include there, and that's where I think we need to do more detailed process level models to see well, what could happen, and then try to abstract it in there. Because it is such a complex problem. But --

MR. WYMER: Right. And my second and final question, observation probably, is that you're not talking about the water chemistry in the waste package, but how about chemistry below the waste package when the water starts passing through a lot of other reducing materials and it quite dramatically change the nature of what actually is then getting out and being transported. How do you deal with that?

MR. MCCARTIN: Well, right now, the only thing we have, we do have the invert, we account for transport through the invert, which could have some properties, but it doesn't account for say that the -- your water chemistry is quite a bit different than the typical -- I mean, it's got the things from the titanium drip shield, the waste package, all kinds of stuff. You know, right now, yes, that's another thing I'm --

MR. WYMER: That's going to have a

considerable, if not profound effect on what happens.

MR. MCCARTIN: Right.

MR. WYMER: Okay. That's just two observations.

MR. GARRICK: Tim, picking up with just a second on what Rod Ewing was talking about earlier.

One of the things, of course, that's very interesting here would be to make comparisons between your results and TSPA results. And there's some obvious points at which comparisons can be made. And the most obvious is the beginning and the end, what input data you're using and what results you get.

But I think what's also important is to be able to pick intermediate spots or pinch-points in the two approaches, in spite of the fact that they're very different, where you can compare results.

Are you attempting to do that, and where are some of the critical -- what are some of the critical intermediate results that you think lend themselves to comparisons?

MR. MCCARTIN: Well, we certainly, even in the VA, we attempted to take what DOE used as input and use it in our code, to the extent practical.

Sometimes you have to tweak a model, some of the data. Obviously they're developed by different groups. Some of the models are slightly different. We can try to represent things.

MR. GARRICK: I think that would be an example of something that would instill confidence.

MR. MCCARTIN: Sure. And --

MR. GARRICK: To not just look at the beginning and the end, but be able to look at what happens when you begin to crank this stuff through a logic engine.

MR. MCCARTIN: Oh.

MR. GARRICK: And your logic will be different than theirs, and if you get likely differing results, that's one thing. If you get the same, that's another thing.

MR. MCCARTIN: Right. And certainly, the intermediate outlooks when we look at DOE's PA are critical.

MR. GARRICK: Uh-huh.

MR. MCCARTIN: How many packages give what.

MR. GARRICK: Right.

MR. MCCARTIN: That is a critical aspect. How much water actually gets into the waste package. They have a particular patch model that determines that. There's all those things, and you're absolutely right, the intermediate outputs.

The only thing, I guess, I would preface it with, is the fact that they -- we might match with our code doesn't help DOE much.

MR. GARRICK: Yeah.

MR. MCCARTIN: That's nice. But ultimately, it's what has -- what is the basis DOE's provided of why their performance assessment provides a reasonable representation for us to make a decision.

And certainly, you know, you're right, but just the fact that we might compare isn't that or --

MR. GARRICK: Where I see this as being very valuable, is in getting a better handle on the uncertainties. Because the uncertainties will be promulgated through the model in some systematic fashion in both cases. And if you begin to ask your -- if uncertainties begin to play a major role in the bottom line results, then it becomes important to be able to back track the results to where you might be able to do something physically or mitigated-wise to deal with those uncertainties. Or maybe it's just a modeling problem.

MR. MCCARTIN: Sure. Yeah.

MR. GARRICK: Yeah.

MR. MCCARTIN: Yeah, it's -- and I'll say probably the healthiest aspect of the performance assessment between ourselves and DOE is the fact that we're -- we share results, we interact. We like to understand, well, how did they get that result. We don't necessarily see that in our code.

And I'll give you a prime example of that. The release, which is incredibly important obviously, we get similar kinds of numbers for drastically different reasons.

MR. GARRICK: Yeah. Well, the way I would characterize that is the source term.

MR. MCCARTIN: Yeah.

MR. GARRICK: Yeah. And that's -- you know, that's where the ballgame is, is what kind of source term you're reading in here.

MR. MCCARTIN: Right.

MR. GARRICK: Okay. Rod?

MR. EWING: Just one brief comment following up Ray's comment. I noted, as Ray did, that the water chemistry inside the waste package is not considered corrosion products, et cetera. And that's not a planned improvement, but I wanted to point out, that will, in fact, have a profound effect on less wasteful on release, formation and ability. Even the discussions of criticality depend on what's going on in the waste package and the corrosion products.

So -- and it's a longer discussion, but it seems to me some of the planned improvements may not be possible without assess of the processes that aren't in the list finally being on the list.

MR. MCCARTIN: Well, I would say that some of those corrosion products could be. When I included the additional chemistries, part of that would be we would include specific chemistries that affect the release rates, which I think would hopefully -- if it appears a significant effect, would account for corrosion products, the less waste form clearly is different kinds of things that will be occurring and don't have the model.

MR. EWING: Right.

MR. GARRICK: Jim?

MR. LESLIE: Tim, this is Bret. I'd like to try to amplify his response. What we're looking at -- and also to reflect something of what Ray said. What we're looking at in terms of including new capabilities for the code, are those things that would detract performance?

The licensee is perfectly capable of deciding what they want to take credit for. And for instance, they want to try to take credit for all that mass absorption, then they would have to provide the database.

We have that capability currently to do it, but it's not our responsibility to determine what their licensing safety key should be.

So while there might be a lot of great

chemistry that could enhance performance, we're not going to add to the code until the DOE suggests that they're going to take credit for.

MR. WYMER: Bret, I would say that just so you have the capability of addressing it if DOE decides to, that's all that really is necessary to ensure that you have the capability.

MR. LESLIE: And we have that capability in the invert model already. We just -- we don't use it, because they take zero retardation in the engineer vario-system.

MR. GARRICK: Jim?

MR. CLARK: I'd just like to support what John said yesterday. I suggested maybe a look at uncertainty and what they're doing, and as a way of checking consistency and identifying areas of concern, and there would be a, I think, very useful thing for you to guys to do as well. And to looking towards the day when you have two models with results which may understandably differ for good reasons, and support each other for other reasons. Just that whole topic of how uncertainty is handled, I think is going to be very important.

MR. MCCARTIN: I would agree. And hopefully Dave Esh will be presenting some of the sensitivity analyses that we've done that might provide a little more information.

MR. GARRICK: All right. According to the clock, our break is over. Thanks, Tim, that was very good.

All right. Let's take a break, and let's keep it, if we can, to ten minutes. Thank you.

(A break was held at this time.)

MR. GARRICK: All right. Moving right along. Our first speaker this afternoon, and we're now talking about the session that's labeled, capability of NRC staff to evaluate risk significance of information submitted by DOE for postclosure. And the lead off speaker will be David Esh. And I'd like each speaker to just briefly say who they are and the organization they represent, and the work they've been doing.

MR. ESH: I'm David Esh. I'm in the Environmental and Performance Assessment Branch of the NRC. And I came there from Argon National Laboratory, and I work primarily on the TPA Code, but pretty much anything related to performance assessment.

And I'm going to talk to you about kind of the analytical analyses, methods and techniques that we do in performance assessment, which is some of the things we discussed earlier.

Do we believe what the code is generating? Does it make sense? You know, that type of analyses is really what I'm going to talk about today.

This little picture here is just kind of how I view or how maybe we view how performance assessment fights into high level waste. And as somebody pointed out to me earlier, this may imply that it's endlessly cyclable, but that's not the impression I want it to give. But these are the main components from a PA perspective that we do.

And I'm going to talk about the bottom line importance and sensitivity analyses, but they all relate, they all influence one another. It's kind of the program is coupled, to use a key word.

Why do we do this? Well, one of the main reasons that we do this is, it's a crucial step in implementing the risk-informed, and performance based regulations in high level waste, because you can't really do that unless you know this thing matters more than this thing. Or this thing I need to worry about, and this thing I don't need to worry about.

So that's one of the main reasons why we go at it, and I also want to highlight the second bullet here, which is we can evaluate the impact of uncertainties that are not in the model, by doing analyses, stressing things further than what we expect, being creative with our analyses.

So sometimes you can address some of the concerns. You know, maybe it's a patch to a problem that might not be very agreeable to some people, but it is a somewhat of a solution, and you can just judge for yourself when you see some of the things that we can do, and some of the things that we would expect the DOE to potentially do.

But we need to evaluate the risk significance information submitted to us by the DOE. That's the key goal here. So we do this analyses, we compare it to that information that they will give to us, and we'll say, you know, yeah, we believe that. Yeah, this thing is important, this thing is not important.

And by independently doing this analysis, we also developed the questions that we should ask about the methodology. You know, I'm going to show you first off some importance analyses, and one of the key questions there is, how much the level of under performance you assign to a barrier.

So the importance analyses, I called them subsystem under performance, they're really ISI's kind of, and ISI's are integrated subissues for -- if we didn't identify that accurate earlier with our acronym.

But there's two types here that I'm going to talk about, and feel free to interrupt me at any time and ask questions.

One is, we want to -- the first type of analyses is evaluate the significance of a subsystem, and you're kind of asking the question at least, what I thought about this and when we did this is, what if I'm wrong about this. You know, how wrong can I be is kind of what you're getting at.

And they have a couple of options here about how you can do this analyses. The justification needed for level of under-performance. Well, you could -- say you have a parameter, I and I retardation and alluvium, and it has a value of like five to ten for the retardation factor.

Well, you could under-perform that, set that at like 5.5, and maybe say, that's an under performance, because my speculated value is going to be 7.5.

Or you could say, well, I'm going to set it at three, take it outside of the distribution, that's an under performance, because maybe there's some uncertainties related to iodine retardation that aren't in the model.

What if you take a -- you completely neutralize it, set it to one. Iodine's going to move at the speed of water.

So what we tried to do in this analyses, is we felt somewhere in between. We didn't operate within the probability distribution functions, we didn't completely neutralize things. Because, in my opinion, the complete neutralization, while you may get an answer, it's not really meaningful. Because some of the -- you can't physically get as bad as you can if you take something out completely.

What it was, if you operate within the probability distribution functions from many parameters or subsystems, you might not be completely addressing the uncertainties that aren't in those parts of the code or in the model.

So I call those one-off, but they're really everything's working as you would expect, and then one part of it is under-performing, so it's not completely out, it's just under-performing.

And then the same thing likewise, would be one-on calculations, they're self-explanatory. Nothing is working except for that one piece, and you get slightly different answers and we'll see that there.

On page five is the acronyms that we used. I just did that to simplify the figures, so you can refer back to it if you need to. Hopefully, they're somewhat explanatory.

I did notice an error. In the figures, I used

"Bio" for the things related to the biosphere and here I identify Dose, so just be aware of that.

Okay. But here's some results from under performing different subsystems with a nominal scenario. And what you can see from this is, when we under perform the engineered system, the Ace package and the drift shield, that is the largest response.

It's kind of like we have this old radio or whatever, and we're turning the knobs and we want to see when we turn the knob so much, whether we get a clear signal from the station or not. I don't know whether that's a good analogy.

That's kind of the way I think of this. We're tripping all these knobs and we want to see what happens. And what we see happening here, is we're getting a lot of performance out of the engineered system, duh, we already knew that.

Well pumping, actually get quite a bit. How much the critical group is pumping, whether it's a farming scenario, residential scenario, a lot of work went into defining the well pumping scenario and the development of the regulation, and I think they felt they chose conservative options when they developed that.

So this is even -- maybe we shouldn't even evaluate well pumping, because they already conservatively set that. But I did that anyway just for completeness.

The saturated zone, SZ1, SZ2 --

MR. WYMER: These are in 10,000 units?

MR. ESH: These are in 10,000 units, yes. And these are peak of the mean though, stock mean of the peak. So it's what we regulate on.

The critical group, transform the saturated zone, well pumping and waste package, engineer barrier system and conduct is what it boils down. For -- this is kind of how our model is working, and the phenomenal scenario.

The one-on evaluation is basically nothing is working, and you compare that one of these things is working, and see how much it can reduce your dose.

Of course, when nothing is working, your doses are quite large, but what you kind of see is that the engineered barrier system, the well pumping will get you a lot. But then also, the radionuclide release rates and solubility limits, and the quantity and chemistry of water.

Now, the interesting thing here when I did this, was saturated zone one and two, while in the flow and transport in the unsaturated zone don't show up really as getting you a whole lot. And that's because in isolation, they don't get you a whole lot.

Flow-through porous media doesn't get you a lot. Retardation and fracture of media doesn't get you a lot. You need flow and transport through porous media to get you a lot in our model. Now, this is based on our model.

So I did that calculation where I turned on both saturated zone flow and saturated zone transport at the same time, and you got a production dose of about 200. So that's -- that type of thing is the type of thing that we hope to identify in this analyses, so that DOE does analyses and presents information to us. We know what questions to ask them.

And Dick Codell has been working on an extension of this, and I'll talk about that later using the factorial design to maybe pull -- more fully evaluate the problem.

MR. GARRICK: Now, Dave, when you do this turning on and off, and you're talking about something like flow, I can see how you don't have to change much downstream --

MR. ESH: Sure.

MR. GARRICK: -- in the model. But if you turn off something like an engineer barrier, like the drift shield or the invert, --

MR. ESH: Sure.

MR. GARRICK: -- where it might have a major impact on the chemistry that takes place during the source term development stage. Do you account for the downstream effects of the off-condition, or are they treated separately -- differently than they were before?

MR. ESH: I did try to take account for that. For instance, like in the flow factors, how much water did this perforating in this uniform sense, how it gets modified and what gets into the drift.

We have a number of components that define that, and like one of them is a large scale focusing, diversion or focusing phenomena that we say could happen due to the UZ geology. That's one component.

Then there are four other main components to that. One is a capillary diversion at the surface of the drift, one is film-flow in the surface of the drift. One is the effect of corrosion products within the partially failed package, preventing water getting in. And then there's also the effect of the intact package itself, the extent of the degradation of the package.

Well, if I go to neutralize the package, then I can't be taken credit for --

MR. GARRICK: That's right.

MR. ESH: -- it's still diverting some of the water.

Now, maybe we can argue otherwise and say, if I want to look at these things in kind of a theoretical sense, what could it do, then I still leave that phenomena in there. Maybe you wouldn't, you know.

It takes some thought, I think, on the analyst's part to make sure they don't create those problems. And they're also trying to be cognizant of how you should do the analysis, you know, you just don't blindly take -- turn things on and off and, you know.

Let's go back a second to the slide before this.

Now, one thing I would highlight here, and I think I mentioned it later. Where we say, well, okay, we need to worry about engineer barrier system and well-com bay and saturated zone biosphere. Well, no, not really, because how do you get the NG1 to this state. This state was characterized by the drift shield failed between 50 and 1,000 years with a mean of 500. The waste package failed between 1,500 and 3,500 years, I think, with a mean of 2,500.

Some sort of, well, yeah, I could -- the reasoned argument, maybe you could get this performance out of it, because we do expect the repository to be dry for roughly 1,500 years, due to the thermohydrology.

So it's unlikely you could -- is it physically reasonable? It could fail all the packages times zero, and I would say no, but then you start running into, well, what could you have happen, and to what extent.

But the mechanism to get widespread failure of the engineer barrier system in early time, is either via aggressive chemistry or maybe mechanical. We already have mechanical effects in the model. Maybe there are some sources of uncertainty in the mechanical model that we need to further evaluate. We continually do that.

But really, it would require aggressive chemistries that say you didn't test yet under chemistries you didn't expect. Maybe you have thermohydrological processes that react to the rock. That, in combination, decrees the grout around the rock bolts, well, the rock bolts also degrade, they create this chemical see (phon.), that gets to the waste package and then you have evaporation of the water, you form crazy salts, and you know, it gets really complex, and I think that's what Dr. Wymer was getting at earlier.

At least maybe we're working on that, a group of us and PA, and a number of people at the center, to try to more fully evaluate all those permeations of chemistry we may get and what that means for these surfaces of these materials.

So if you look at the analysis blindly and say, well, you know, I'm only worried about these three things, so not worry. Not really. You know, you need to use some thought even when you look at the results of the analyses.

MR. GARRICK: And you're doing that?

MR. ESH: And we're doing that, yes. And that's what we -- what we would hope is DOE does analyses like this, and we can understand from them how their models are working, what we should worry about, you know, questions we should ask.

It doesn't address the question -- well, in a way it does. Most of these under performances are way outside of the probability distribution function. So like when you look back here at say, UZ transport, all the distribution code emissions are set to zero. No retardation of anything in the UZ.

Obviously, you're going to have some retardation of highly sorbing species in the UZ to some degree, no matter what. Maybe you're not going to have a retardation factor of 100,000, but you don't need it. You know, maybe you're going to get 50 or 100 at least.

So many of these analyses were really stressing this thing hard, and this is the picture that you get from that.

MR. WYMER: I don't have an understanding of this one-on concept. Suppose you just turn one thing on, like mechanical disruption of engineer barriers. Does that mean that there is instantaneous transport of the radionuclides from the drift, the 20 kilometers, there's nothing in between retarding anything?

MR. ESH: No. Say like what you're doing in a one-on and say I only have waste package working. The waste package -- or waste package and drift shield. The waste packages and drift shields are working as we expect them in our nominal case model.

Everything else is under-performed, but they're still working. So like you may have a minimal travel time through the UZ. You may have a minimal travel time through the SZ.

MR. WYMER: So you put them --

MR. ESH: You still have the wells pumping at a residential community rate instead of a farming community rate, you know, --

MR. WYMER: Things don't go to zero at one time?

MR. ESH: They don't go to zero, no.

MR. WYMER: Yeah. I think at one time, the concept was you turn things totally off, and that really is not sensible at all.

MR. ESH: Well, that's what I thought. I felt like, well, it's nonsense. Well, sure, I can generate some numbers, but what do they mean. So I tried to do something I thought well, it's still not maybe sensible, depending from your viewpoint, you know. But at least, from my viewpoint, it's somewhat less sensible.

MR. WYMER: One more question. UZ1 is described as climate and infiltration. What do you mean one-on and one-off in that case?

MR. ESH: So when climate and infiltration is working, we have the infiltration rate, it's between a uniformed distribution of one to ten millimeters per year. When it's off, it was set to I think 30 millimeters per year. So three times higher than the maximum value was how it was under performing.

MR. WYMER: It held at that constant value?

MR. ESH: Yeah. You could assign a range to it. You could do a number of things, you know. It's subjective, but I tried to use some sort of reason.

That wasn't the only thing though, like there's a number of climate parameters. These are subsystems, so there's a lot of parameters that were all tweaked at the same time, not just one parameter. So it may have been -- there's a parameter that defines the climate cycle and how much infiltration you get based on the temperature changes. That was altered. You know, a number of things were all changed at the same time.

MR. EWING: So it's essentially on and off between climate extremes wet/dry?

MR. ESH: Yeah. But all things are not equal in terms of importance and nor would you expect that in a natural system. Some things are going to be more important than others.

The level of under performance selected as important. Of course, like for some of those things that didn't show much effect, they're practically -- they were practically taken out of the analyses, so I can't under perform them anymore and show much of an effect.

The waste package and drift shield, I couldn't under perform it more, and I did that calculation, setting them both -- taken out at times zero and I still only got a D3 mills, like a 32 milligram or something like that.

I talked about the consideration for quantity and chemistry, and you get different answers, kind of depending on what type of analyses you do. And I'm going to move on to the sensitivity analyses, it's another set of different answers.

And so what we basically did with sensitivity analyses is we want to evaluate which parameters or subsystems are contributing to variability and the output. It's kind of traditional.

I think both Dick Codell and Sid Metacalantha (phon.) have talked to you in the past about a lot of their work that they found in this area, and it's really good work. Neither of them were able to be here today, so I'm going to talk a little bit about where we're going in that area and some analyses we did at the substance of multi sensitivity.

But these are kind of with inside the model then which things are contributing the variability and the output, that's what this analysis is going to show.

We evaluated a number of techniques. We settled on one that's tended to yield the most stable results, and I'll comment on that in a slide coming up here.

Basically, we generate a CDF of our nominal response, then if we want to look at say, climate and infiltration, we'll set all the climate and infiltration parameters to their mean values with a very small distribution, a very small range to preserve the random number sampling, and then we rerun the calculation, and if it changes the CDF, then that subsystem is contributing significantly to the sensitivity.

If the CDF's are the same, that subsystem is not contributing to the sensitivity. Each of these runs are full Monte Carlo's with thousand vectors, and actually, I tried to -- I started looking into well, can I make the conclusion of this guy is more -- say, NG1 is more sensitive than BIO1, for instance.

And to do that, I had to look at the stability of the results, and so I ran the analysis three times through with different random number sampling, 1,000 vectors per simulation, and I developed those compulations and -- not at statistical confidence intervals, but I can kind of look at the data and see it's highly unlikely that doing this analysis, the results are going to fall outside of those ranges. And I ran it up to 50,000 years to try to see if things made sense, based on how the model.

So this figure, I hope you appreciate, is -- represents like 40 days of computer time. So this -- we talk about complexity in adding things in and, you know, you started running into a cost benefit where things get prohibitive. So you have to try to preserve the uncertainty and all the underlying phenomena processes, but still make it runable so that you can do analyses and make sense of it. And that's the constant battle that we have.

So this figure is a lot of computer time, and what you see is the engineered system, and some things in the near field, one in chemistry, your release rates and solubility, climate and infiltration, saturated zone flow and transport, well pumping, and placed that on a critical group, all contributed to the sensitivity in 10,000 years.

And then, I did a lot of further analyses to explain why things would decrease from 10,000 years to 50,000 years, and a lot of that is contained in the back-up slides, which we would be -- I would be happy to discuss, I mean, if that would -- for instance, why the Brendon Clyde (phon.) transport, lower transport in the UZ's show up as doing a lot, either in the importance analyses, or in the sensitivity analyses.

One of those is contained in the backup slides, and maybe if we have time, which I doubt, we can look at those.

We'd also do sensitivity analyses at the parameter level. And this is a lot of what was reported to you in the past.

That analysis is ongoing for the SR case, the new design, the new parameter values, et cetera. And generally, applying the same methods which were used in the VA, and basically, a number of different techniques listed here were all evaluated, and then the number of times a parameter was identified as being sensitive with each of those techniques, say like, juvenile failures shows up with all six of the techniques that received this six of six.

And then using that procedure with every parameter in the TPA Code, they just filled out basically in the GA, 19 parameters were identified as being pretty sensitive.

Where some things that Dick wanted to talk about, but he was not here and he was unable to, are the factorial design and neuro networks, which is what I'll go in to now.

MR. CODELL: I'm on the line?

MR. GARRICK: Yes, San Antonio. Richard Codell from the speaker phone.

MR. ESH: Oh, good.

MR. CODELL: From Washington. I just wanted to tell you I was here.

MR. ESH: All right, Dick. Thanks.

MR. CODELL: Okay.

MR. ESH: So the factorial design was spurred because DOE intends -- or they expressed the intention to us to evaluate parameters of the fifth and ninety-fifth percentiles and use that as a way to identify which parameters are sensitive.

And, of course, a complete sampling of all combinations requires them to be M samples where M is the number of samples for parameter 2 and 3, and N is the number of sample parameters.

So you have a lot of parameters and you want to look at a couple of states, you end up with a very large number of fermutations in a hurry.

So Dick did a lot of analyses with factorial design, to see if he could do partial factorials, and what he could still identify the sensitive parameters. And within our computational budget, which is a concern for us.

And here the main advantages and disadvantages. Advantages, rich literature, less ambiguous than Monte Carlo and allows an easier analysis. Multi-parameter sensitivities, which is one of the things that we didn't do DOE on.

Disadvantages of factorial methods are really having only two samples per parameters, honestly effects that might be important in the middle of the range, and use three at a price, but that price accelerates very rapidly when you have a lot of parameters.

And if you do a less than full factorial, then you might get confounding of say, single parameter facts with multiple parameter effects, et cetera.

But the simple model is this, and he designed it to be -- to give them highly skewed results, which is what we get from the TPA Code. And it's just really simple, we wanted to test the method, and see whether it'd be able to fly it with the TPA Code, and so he got a source term at M curies, and all these ten parameters were represented by uniform distributions.

At M curies at fail time T fail at a half 1,000 years, the number of different transport properties, and a couple of properties for their receptor model. And two of the transfer of properties were selected to have no effect, so that he could see whether the technique would identify those which weren't sensitive.

And you may say, well -- I asked him the same question. Well, why wouldn't the effect of porosity have an effect, but it was the way he abstracted it with the mass transport that it would have truly no effect in the model.

And the results are shown here with these bar charts. Basically, he did the full factorial, which required 1,024 runs, and he identifies sensitivity of the various parameters, and these are the two that were selected to be insensitive were, in fact, identified as being insensitive in the analysis.

Then he did a number of different partial factorials, and concluded that you can still identify the sensitive parameters with the partial factorials, but you start running into confounding effects as I mentioned earlier, and you might -- if you reduce it too much, you might make inaccurate conclusions about what is sensitive and what is not sensitive.

He's compared the results of the factorial analysis with LHS, concluded the factorials at a reduced factorial state was better able to identify sensitivities than the LHS method would be.

So that -- basically, this is a summary of that comparison of the factorial and shows good results. Comparisons between the factorial and LHS showed the ability of the latter deteriorating greatly, for fewer rocks containing the back-up slides.

And also he did a lot of work with the parameter trees identifying what sequence of parameters or a combination of those parameters lead to the highest doses. That's something that the regulator is concerned with.

And he wanted to state that the ANOVA techniques can easily be applied to the results of these calculations.

So our path forward is kind of -- is developing this design or to say we're developing this design for all our sample parameters, or a lot of sample parameters, which is around 300, a question that Rod asked earlier, how many sample parameters we have.

And basically, the full factorial. For the system under performances that I talked about earlier, what I was concerned about was the effect of multiple under performances for multiple things on at the same time, which ones of those -- which combinations give you the biggest effect. And we can do that analyses, too, with this factorial design.

The full factorial would take like 2,048 runs, which would be too much for us. But the partial or the combining flow and transport, taking it down to seven subsystems would give us, I think, 128 runs, which we could easily do, would just take a little bit of computer time.

But that's what we're headed with the sensitivity analyses. And the main conclusions from all of this, is that the code I think is flexible enough for us to do our job.

Sometimes you've got to think and use your brain, too, when you do this sort of stuff, so that's why I wanted to highlight it and that's what we'd expect from the license applicants.

And it's important to do a number of different things to understand, because you get different answers, and you also want to be cautious about the conclusions that you make, so if something isn't in the model, of course, you can't see it, no matter how much you take the model apart, you can't see that effect.

You can do that, to some extent, but under performance could say, well, this is the effect, it's not in the model, it's going to result in an under performance of this type, and then you can, in a way, identify what the impact would be.

Tim McCartin is going to talk about the last presentation of this segment, pro-active and reactive uses of risk information in high level waste project, which is something you've asked about.

And my last main conclusion is that if you focus on these key parts, and you have a finite amount of effort available, you're going to necessarily most adequately protect public health and reduce unnecessary regulatory burden. If you had an infinite budget, then, of course, you could study all these things, and as not, that isn't realistic either, so.

There are a number of slides in the back-up that we can talk about if you'd like. I'll open the floor for questions now if you have any additional.

MR. GARRICK: Okay. Milt?

MR. LEVENSON: No.

MR. GARRICK: Ray?

MR. WYMER: No.

MR. GARRICK: What's happened. George?

MR. HORNBERGER: Dave, some of your sensitivity results, for example, your slide on page six where you did your one-off show a really big bar for the engineering subsystem, ENG1, okay. And some people when they see these kinds of results will immediately infer that what that means is that the engineered barrier is the only thing that is securing the waste at Yucca Mountain.

How do you respond when somebody infers that and asks you a question on it?

MR. ESH: Certainly it's contributing a lot more into the performance, but if it was the only thing, this number, this 25 would be much, much larger than what's shown on the figure, it was the only thing.

So I didn't show those values specifically on the one-on, I don't think I converted it in a factor, but the doses are much, much larger than that. If you only have one thing, say, engineer barrier system, when you turn it off, you're going to get a much, much larger dose than 25 millimount.

MR. HORNBERGER: So you're confident that the kind of analyses that you have done and have planned will be adequate for investigating the level of contribution of different systems to the overall performance?

MR. ESH: What I would expect is, you know, we do this analyses to try to understand what should be considered while you're doing the analyses, and how things are working.

I think we would expect from a license applicant, that they would do whatever analyses they think are appropriate, and they would make a justification for why they are identifying which things are contributing for and how they're contributing, et cetera.

So like in the figure six where the unsaturated zone isn't showing much, that's because this -- for nominal cases, what Tim highlighted on earlier, we're primarily looking at iodine and technisim getting out, 99.9 percent in 10,000 years is iodine and technism chloride. Everything else is retarded.

And a lot of it is retarded in the unsaturated zone. So it is contributing to a barrier, but it's not contributing to the things that are showing up as risks in our analyses.

So you can look at the problem a number of different ways, and come to different conclusions, and that's what I would stress is you do as much analysis as you can to allow somebody else to make their conclusions about how things are working, and not just do say, one analyses and say, this is what it is. Because you get different answers on how --

MR. GARRICK: In the middle of your conversation or your presentation, you dropped a number of

32 milliram.

MR. ESH: Yeah.

MR. GARRICK: Per year. What was that for? For --

MR. ESH: That was when I failed all of the waste packages and drift shields at times zero.

MR. GARRICK: Failed all of the waste packages at drift shield?

MR. ESH: At times zero.

MR. GARRICK: Now is that -- was that result a surprise?

MR. ESH: It was a surprise it wasn't higher than that.

MR. GARRICK: Yes, I'm impressed with that number. Why are we spending the money we're spending to build -- to design this? That is an impressive result.

MR. ESH: Well, you know, I would like to see that result from the DOE and see what that number is.

MR. GARRICK: Yes. Yes.

MR. ESH: Certainly, that would be a good comparison.

MR. GARRICK: Yeah, okay.

MR. ESH: But, yeah, it's not a question for me to answer.

MR. GARRICK: I understand. Okay. Rod?

MR. EWING: Going back to the parameter unsaturated zone one, where you have wet and dry climate, why does it have such a small effect?

MR. GARRICK: It has a small effect basically because the engineered barrier system, retardation and the unsaturated zone, the well pumping, or retardation flow and transport in the saturated zone, and well pumping are all still working. You know, when you have that under performance of the climate.

So the climate may be changing flow, and it may be increasing the amount of water that are getting to the packages, but you're still in that 35 packages failed. So you can't -- even though you under perform climate, you're still only able to release from those 35 packages that have failed. Because that's why you see it really doesn't have a large effect on this type of analyses.

Now, if you do the -- I'm sorry. If you do the full factorial, you may see the climate has a bigger effect when you start getting to those combinations of things, turned on or off. You might --

MR. EWING: You know, going back to George's question though, isn't this the answer that I think you didn't want, that is that the repositories, essentially, the engineer's variable.

MR. ESH: I don't interpret it that way. But sure, it's open to interpretation.

MR. EWING: It sounded like it from here, but -- and then finally a comment. I understand why, you know, to make risk informed decisions, the vertical accesses in milligrams per year, but in fact, in order for the scientific community to think about the results of the analysis, it's more useful to maybe break it down by principle nucleis, so one can think about the chemistry and the process, and see where the major contribution of doses come from.

MR. ESH: Well, let's look quickly, I know I'm over, but let's go to slide 23. We have just a minute.

MR. GARRICK: Only a minute.

MR. ESH: Only a minute. Okay. Slide 23 is basically for a base case listing release. The average here is released from the engineered barrier system, the unsaturated zone, and the saturated zone. And this is the type of analyses we do with our model, to say, does this make sense. Do the sensitivity results make sense, do the under performances make sense, you know. Should I believe this, how is the thing working. Those are all the questions we know how to answer.

But you can see from this, that iodine doesn't -- in terms of curies, may be you should normalize it based on a source term, but it isn't the highest released, but it gets out, you know, plutonium, neptonium are basically knocked out by the NSE.

And there's a lot of other analyses back here about say the unsaturated zone and saturated zone that I encourage you to look at, as the type of things that we do.

MR. GARRICK: Jim?

MR. CLARK: No thanks.

MR. GARRICK: Andy?

MR. CAMPBELL: When DOE -- the question John raised earlier about the -- when you fail all the waste packages, you're looking at doses that are pretty close to the regulatory limit. Now, is that a 10,000 year calculation?

MR. ESH: Yeah.

MR. CAMPBELL: So if you go out in longer periods of time, you may see a growth of radionuclides that are significantly retarded.

MR. ESH: Yeah. You certainly see an opportunity comes in 50,000 years, like there's a pie chart in the back here, that shows in 50,000 years, 75 percent of the dose is from neptunium.

MR. GARRICK: If that's true, I take back everything I said about the natural setting.

MR. ESH: So, yes, you've got longer times, the numbers get different. You've re-established his belief in the impact areas. I might do a follow-up to that. DOE has done these things called neutralization analyses where they "neutralize" the waste packages, and they get substantially higher doses even within 10,000 years. I mean, orders of magnitude of higher than you're talking about here.

MR. CAMPBELL: Now, is there an effort ongoing to try and get to the reason why that is the case?

MR. ESH: Yes.

MR. CAMPBELL: I mean, the licensee has orders of magnitude of doses than the old estimates by the regulator?

MR. ESH: There is an effort to get to the bottom of that, and that's what we hope in the analyses that DOE gets us, that they provide enough information that we could determine if that is the case, why that is the case, for instance.

And one of the main things we've discussed with them is, they have a diffusion model, that as soon as they form a hole in the waste package, they send water from the humidity and the air couldn't get in there, and then you have no resistance pathway from the fuel in the package to maybe this micron-sized hole, it's instantly transported from the fuel to the outside of the package.

And, you know, maybe they don't want to try to collect data to take any such a credit for that phenomena, but maybe it's driving those doses, whenever they do a neutralization, they have a huge diffusing release that's causing those large values.

But certainly we would want to get to the bottom of, if there are substantial differences between this model and their model, why, you know, what are the sources of that.

MR. WYMER: One of the most disturbing things I've heard today so far was the statement that -- and I understand DOE arrived at the same result for widely different reasons, that inspires confidence.

MR. ESH: Way to go, Tim. Let me comment on that, that was the source term issue though.

We have effective release from our source term, and they had a high diffusive release.

MR. WYMER: Okay.

MR. ESH: And so they gave the same results for that -- on to the specific problem that he was talking about, although it was through different phenomena, there's diffuse of ours has actually been --

MR. WYMER: Oh, I see. Okay.

MR. MCCARTIN: Yeah. They take credit for -- which knocks their source to fuse and release down quite a bit. We do not take credit for clatting, but we don't have the diffusive releases that we believe -- while we have primarily an effective release model. And so our release rate is lower, no credit for clatting, their release rate is higher, no credit for clatting.

MR. WYMER: So once you --

MR. MCCARTIN: We end up at about the same place, but they are very different modeling assumptions.

MR. WYMER: So instead of being disturbed, you're gratified?

MR. MCCARTIN: Well, we need to understand what the Ph represent, and in essence, we understand when the PA's represent, yes.

MR. GARRICK: And this is interesting stuff, and I'd like to dwell it on a lot longer, but I guess we better move on. Thanks a lot, Dave.

Okay. Our next speaker is Stan Kaplan. Stan, tell us who you are, et cetera.

MR. KAPLAN: I'm Stan Kaplan and I'm consulting to the Sensors for Nuclear Waste here. And the problem we're talking about is producing a graphical post-processor for the TPA Code.

The purpose of it is to make the results of the TPA Code transparent. Transparent, of course, means we want to be able to see through, so we want to be able to see through these kinds of numbers that come out of the TPA Code, to see the things we'd like to learn.

So what are those things. Well, we'd like to see whether we're getting the same results out of the TPA as DOE is getting of theirs.

We'd like to track quantitatively the movement of water and isotopes through the overall model. We'd like to clarify the effects of the individual submodels on that movement. We'd like to visualize and understand the overall repository performance and effects of design features, site characteristics.

We'd like to understand the uncertainties and the parameters in the models, and the effects of those uncertainties on performance. And we'd like to examine the effect of assumptions and candidate possible design changes.

So in response to that desire, we have an idea for a graphic that would explain the performance.

I'm showing you here the original hand-sketch, what this display would look like, and we call it a performance summary diagram.

So against the time axis here, this shows the rainfall coming down. This shows -- this curve, the water that gets below, that actually infiltrates into the ground below the root level and the transpiration, et cetera.

The next one is the water getting down to the surface of the drift. The water then enters the drift. The water that falls on the drift shield and here we're characterizing somehow the integrity of the drip shield, which after a while deteriorates. Which after a while deteriorates, allowing the water to reach the canister, waste canister.

Shortly after that then, we begin to see a release from the waste canister. Release from the barrier, this curve like that, and release from the unsaturated zone and release from the saturated zone and finally dose to the target.

So that was the concept. And the idea was on one page you could see a statement of the whole performance of the repository through a -- and all the intermediate steps.

And I showed the difference between water falling on the surface, and water getting into the ground and such, to recognize that -- these are opportunities perhaps for engineered intervention.

So the difference between rainfall and the water getting into the ground that's run-off or transpiration. So I suggest some engineering actions to increase the run-off.

The difference between infiltration and surface of the drift, there's also engineered features that have been suggested, to intercede that step, like Richard's barrier. The water entering the drift, well, part of the difference between the water reaching the surface of the drift, and not entering the drift, is a capillary transport of the water around the circumference.

Without seeing that, there may be -- give us some ideas for some things we can do to increase the capillary transpiration.

So that was the idea of presenting it this way. So this is the original sketch. I'll show you in a little bit, what we -- you know, where we stand with respect to actually having the computer draw the diagram.

So given that sketch, the total performance diagram, we could display uncertainty now in two ways. One would be to display the whole courier as our best, the whole graph, as our best estimate. And then a high and a low. That'll be one way of giving a sense of the uncertainty of the performance.

Another way would be to take individual curves from there and show the percentiles.

Effect of design modifications, once again, we could compare the performance summary diagrams before and after the modification. And we can convey our individual performance curves, or in the probalistic families of curves before and after the design model.

So this is sort of a first version of the computerized reproducing this summary diagram, and we have some work left to do to get the scales right and the colors right, and lineaments right and things of that sort.

But basically here's where we stand. And let me see, there's a -- you've seen that. Precipitation and infiltration the flow reaching drift, the flow hitting the waste package.

We see here the release from the -- canister failure time. I guess the -- I guess this is the pink one on this -- and it shows that the canisters fail within a short time interval of each other.

MR. GARRICK: Once they start.

MR. KAPLAN: Once they start. Now, there is a little piff down in here, which results from -- I mean, it presumes a percentage of defective canisters, so they fail earlier.

So there it is, and what's going on now, refining and cleaning up of these diagrams.

This is a display of uncertainty, by comparing individual performance curves and percentiles. So this is dose to receptor, 10th, 50th and 90th percentiles.

This just shows the effect of the -- building the individual realizations here into percentiles. We're calling that a regular -- a breaking and rising process, from an old language, which refers to this kind of figure as a spaghetti occurs, and this as a regular rise spaghetti.

Here, something similar is done, except we used different colors to denote grouping the spaghetti into five subfamilies denoted by different codes. And then, we have simplifying this by plotting the 50th percentile for each of those five groups in different colors.

So that's where we are. We're just beginning to get these graphs off the computer, and we're testing it and shaking down the little bugs and it looks like it has the capabilities to give us the kind of transparency we want.

MR. GARRICK: Here you can see the results of the PA, Stan, and manipulate them?

MR. KAPLAN: Present them?

MR. GARRICK: Yeah, present them. You're not suggesting any different approach, for example, of calculating the uncertainties themselves?

MR. KAPLAN: No.

MR. GARRICK: Yeah, okay.

MR. HORNBERGER: I'm interested, Stan, on you say that one of your objectives was also to clarify the effects of the individual submodels.

MR. KAPLAN: Yeah.

MR. HORNBERGER: On the movement of water and isotopes.

MR. KAPLAN: Right.

MR. HORNBERGER: Do you think that, in your mind obviously your diagram does that.

MR. KAPLAN: Yeah. And in yours?

MR. HORNBERGER: Well, I'm still wondering a little bit. The -- you know, I'm trying to sort out here the difference now as we come down here between precipitation, for example, precipitation and water hitting the waste package.

MR. KAPLAN: Uh-huh.

MR. HORNBERGER: Now, how am I to interpret that?

MR. KAPLAN: Well, you've got so many inches coming down on the surface.

MR. HORNBERGER: Right.

MR. KAPLAN: And as it goes down, you've got fewer and fewer inches of water.

MR. HORNBERGER: So by the submodel then, you would be saying, okay, it's the unsaturated zone transfer with the focusing factors and everything else that is built into that, and it gives you a sense that -- I guess what I would like to understand better, I suppose, is how, let's say in this case, how the unsaturated zone flow contributes to the performance of the repository.

And I guess what this diagram tells me is that the unsaturated zone diverts a certain fraction of the flow around the drift, but that's not very transparent for me to get -- to take that and say, aha.

You know, suppose it diverted half as much. I don't know what that means over here on the performance side.

MR. KAPLAN: Well, that is a case of parameter variation. We run these runs changing --

MR. HORNBERGER: So we'd have to look at your --

MR. KAPLAN: You're changing your model and design parameters.

MR. HORNBERGER: -- last --

MR. KAPLAN: Oh, no, this is just uncertainty.

MR. HORNBERGER: It's uncertainty.

MR. KAPLAN: Yeah.

MR. HORNBERGER: Okay. Here you would be changing the parameter on the model?

MR. GARRICK: You've got to get to a mic.

MR. HORNBERGER: All right. So I guess what you're saying is that, to fully understand -- she can hear me. Can you hear me? She can hear me.

To fully understand the contribution of subsystems, we will wind up having a family of these curves. In other words, you haven't anviated a need for sensitivity analysis here.

MR. KAPLAN: No. This is a presentation. This one figure summarizes the performance of the repository.

MR. HORNBERGER: Under those conditions?

MR. KAPLAN: Under those conditions.

Now, if you wanted to change the model of how it -- the water drifts down and passes between and so on, that would be another run and you'd get another whole live in like this that we'd put along side.

MR. HORNBERGER: Uh-huh.

MR. KAPLAN: And that would be the difference.

MR. HORNBERGER: Okay.

MR. KAPLAN: Hopefully, it would make sense physically.

Oh, I wanted to say on that. Yeah, another reason for showing all these curves, one is to -- as you said, to understand the workings of the model. Another is to be able to use your physical reasoning, looking at the numbers.

MR. HORNBERGER: I see.

MR. KAPLAN: So is it reasonable that this curve should have this volume, and this curve should have that volume, so we can get a rough physical check.

MR. HORNBERGER: Right.

MR. KAPLAN: And the third one, the third reason for that, is to see opportunities for intervention, design models.

Anything else?

MR. GARRICK: Yeah. I think one of the points that you're also making, George, is that the layman and the public are -- tend to be afraid of curves. And are much more conditioned for looking at tables and --

MR. HORNBERGER: Are you putting me in that category?

MR. GARRICK: No, no. I wouldn't think of doing that. But there are certain presentations they're much more comfortable with, like pie shapes, and isograms, and tables of comparison. And, of course, you can compare mean values as a function of time, you can cast this information in various forms.

But I think one of the things that this brings forward is taking a tremendous amount of information and boiling it down into a simple presentation, a simple comparison to what's behind it. And I think that's the idea. That idea was enormously beneficial in other applications, we found. We have found.

MR. WYMER: I don't know whether it was intentional or not, but if you look at Tim's four points as a means of communicating effectively with the public, those are seepage, waste packages, conditioning, release of radionuclides, transport, et cetera, et cetera, and zone. It's a one-to-one correlation here.

MR. KAPLAN: Completely an accident. We're all trying to do the same thing.

MR. GARRICK: Okay.

MR. KAPLAN: But to John's point, you can't think in terms of this system with a number or a couple of three numbers, you know.

MR. GARRICK: Right.

MR. KAPLAN: Our performance of the system, at its simplest, is a chart with seven or eight curves on it.

MR. GARRICK: This is a --

MR. KAPLAN: If you can hold that in your head, you know, that whole picture. Excuse me.

MR. GARRICK: Yeah, this is a classic example of the old Einstein adage of making things as simple as you can, but no simpler.

MR. KAPLAN: That's right.

MR. GARRICK: And in order to capture any kind of a totality of what's going on, it would be very difficult to get away from the curves.

MR. HORNBERGER: But again, taking this as a presentation, and I accept what you said, but I'll play devil's advocate here.

MR. GARRICK: Why?

MR. HORNBERGER: An unusual role for me. If I look, for example, at the curves of precipitation and infiltration, as we come down, these are very smooth curves, and I look at the curve of the release from the engineered barrier, it's very jagged, which immediately leads me to question whether or not we -- this captures the important mechanisms for what we care about.

MR. KAPLAN: That's a good question. You're referring to this stuff here?

MR. HORNBERGER: Yes. Yes. And down here.

MR. KAPLAN: Yeah. Well, that's a result of the many realizations that we're running. But it's a good point.

Even so, we want to understand exactly how they got there, and maybe modify the form of display, so we don't introduce extraneous stuff, which is unimportant. Maybe it's real, in that it's a real 50 percent percentile, but it's not a real physical thing and it just confuses people.

So it's that kind of refinement that we might have to --

MR. GARRICK: Yeah. It's possible you'll want to address other mitigating features that begin to map more closely with these curves, you know, individual barriers, the performance of individual barriers.

MR. KAPLAN: Well, we have some of the barriers there.

MR. GARRICK: Yes.

MR. KAPLAN: Some we couldn't get because like the water entering the drift is evidently not easily accessible in the TPA Code. There's no file anywhere which lists those numbers, so we haven't sorted out whether and how you can get at them. But that would be a very nice one to add.

MR. GARRICK: Jim?

MR. CLARK: Let me do a sound check first. Can you hear me okay? All right.

MR. GARRICK: This must be important then.

MR. CLARK: I was advised during the break. I really like slide five, and what strikes me about it, is you mentioned design modifications, you just run down all the different components before you get to the repository you can look at. And engineering controls, --

MR. KAPLAN: Yes.

MR. CLARK: Additional engineering controls, and the failure times as well. If that failure time would delay, it would shift the whole curve to the right.

MR. KAPLAN: Yes.

MR. CLARK: So it would provide a tool of deciding whether or not some of these additional things had merit, how much time do they buy you, what does it do to degradation, what does it cost, and it just struck me as -- also as -- well, you know, the plumes at the bottom might take a little explaining, but it struck me as a pretty powerful tool to just show all the different components and how they effect performance.

It struck me as especially powerful in evaluating additional things that might be done.

MR. KAPLAN: Yeah. That's what I was thinking. I want to engineer something, in the mean and control nature. So my head naturally got the --

MR. CLARK: For a landfill, for example, you -- by putting in a cover there, that's one thing that could consider, well, with that cost, how much time would it buy you.

MR. KAPLAN: Uh-huh.

MR. GARRICK: Rod?

MR. EWING: I'd like to make a statement based on figure nine or the figure that's on page nine, so that others can correct me as we pass through the day.

And in this figure, you proposed to display the uncertainty by plotting the different percentiles for dose as a function of year. And the statement I think is that I don't think this captures the uncertainty of the analysis.

The analysis, of course, involves all the hydrology, your chemistry and all of the propagated uncertainty of that part of the analysis. And that's different than the range of values you get per dose.

And the way I would argue this, is if you go the long enough time with decay, the uncertainty would become zero, because everything's decayed away. But certainly at very extended times, the uncertainty of the analysis is very large.

MR. KAPLAN: Uh-huh.

MR. EWING: So I may be wrong, but I think this method of displayed uncertainty actually doesn't -- it's just a range and expected doses.

MR. KAPLAN: It's uncertainty, in that it goes to the receptor, right?

MR. HORNBERGER: I don't think so.

MR. KAPLAN: As a function of --

MR. EWING: It's just the range of values. But those ranges have, let's say, air bars on them, and those values -- those air bars are growing as a function of time. Right?

MR. KAPLAN: No. To use your own example, if a dose goes to zero -- if the dose goes to zero, the uncertainty isn't huge. The uncertainty goes to zero, too.

MR. EWING: The uncertainty of the analysis and the uncertainty --

MR. HORNBERGER: No, the uncertainty of the analysis goes to zero. We're really confident that that goes to zero if it's long enough.

MR. EWING: Now what I'm saying is, at the extreme, that value goes to zero, but the performance assessment involves the analysis of the hydrology, the geochemistry, water flow over time. And there's real uncertainty --

MR. HORNBERGER: Oh, yeah.

MR. EWING: -- with all those parameters.

MR. HORNBERGER: Right.

MR. EWING: Propagated over time.

MR. HORNBERGER: But the uncertainty and dose goes to zero.

MR. EWING: Right. But I think when we talked about uncertainty, we're not talking about radioactive decay. I mean, that's not the big problem here, right? It's the uncertainty and the analysis of the hydrologic and interview systems.

MR. HORNBERGER: That's built in here.

MR. KAPLAN: Yeah.

MR. EWING: But not captured by -- because if we just a little further, you see that -- and you see this in the DOE analyses, due to decay, the uncertainty or the range in values of doses going down. But -- well, let's say if there's a crossover point.

There's a point, and from DOE curves, it looks to me to be between 10,000 and a million years. Where the uncertainty in the analysis, the geochemistry, the hydrology has a big effect on dose, because you still have activity.

MR. HORNBERGER: Right.

MR. EWING: And that's the relevant period of time. And so you want to calculate the uncertainty in your analysis during the relevant period of time. It's not important to calculate the uncertainty at times that are so short there's no release, or times that are so long, that the activity is zero.

MR. HORNBERGER: That's right.

MR. KAPLAN: Right.

MR. EWING: But there is --

MR. HORNBERGER: That's right. But that's what's shown. That window is what's shown here.

MR. KAPLAN: It's not important to calculate it, because we know it already. Is that what you're saying?

MR. EWING: In this window, though, the uncertainty is just not the dose. It's the propagated uncertainty of the geochemistry and hydrology.

MR. KAPLAN: Sure. And all of that uncertainty, finally, what we're interested in is the dose to the people, so all those uncertainties are there, continging on these curves.

MR. EWING: I preface by saying, so I can be corrected. I'm still not convinced.

MR. WITTMEYER: I'm not going to correct anyone. I'm just going to add an extra dimension.

It'll lead into what I'm going to talk about next. In a way, this does more than just talk about uncertainty. It makes uncertainty useable, but we're a decision-maker. It's more important than knowing what uncertainty is, but also how it affects the risk, and this is what this right here --

MR. KAPLAN: Yeah, this -- right.

MR. WITTMEYER: A way of displaying --

MR. KAPLAN: What this has attempted to do is you recall in all of our previous WHIP association, we used to deal with this question. So what?

This attempts to deal with the question of so what. This is the bottom line, and the only reason I'm interested in the uncertainty of subcomponents, is how it effects the parameter that I'm using to measure safety or risk.

MR. EWING: Right, and the so what though, and again correct me. This range of values, say, the 10th to the 90th percentile, those are on individual realizations, say you had 300 realizations, and you picked those boundaries accordingly. But each realization has error bars, right.

MR. GARRICK: This is getting into the uncertainty of --

MR. KAPLAN: That's not the way we --

MR. GARRICK: Yeah. That's not --

MR. KAPLAN: -- treat uncertainty.

MR. GARRICK: No.

MR. WITTMEYER: It may not be the way you treat uncertainty, but I'm saying for each realization, there's a propagated uncertainty, right?

MR. GARRICK: What you're saying is, what's the uncertainty of the uncertainty.

MR. WITTMEYER: Of the single realization you -- there's no error for, right?

MR. KAPLAN: The error associated with uncertainties? I mean, to a certain extent.

MR. HORNBERGER: Just do a single realization.

MR. KAPLAN: It has no uncertainty. What uncertainty are you talking about?

MR. HORNBERGER: You sampled over ranges of -- I see what you're saying, yes.

MR. KAPLAN: The way we express uncertainty is through the sampling. Each sampling does not have uncertainty.

MR. GARRICK: It's a different concept. It's a different concept. I think we better move on.

MR. HORNBERGER: Moving right along.

MR. GARRICK: Moving right along, thank you. Don't walk away with the microphone.

MR. KAPLAN: Uncertainty of uncertainties.

MR. WITTMEYER: I'll try to make this brief.

MR. GARRICK: Okay.

MR. WITTMEYER: It was sort of an interlude to what we've been talking about, but it follows along nicely after the discussion we've had.

I'm supposed to be talking about the philosophy of uncertainty and I've changed a little bit. I'm talking about uncertainty in HLW performance assessment, and actually talking about uncertainty from the perspective of the regulator.

And how you treat uncertainty depends very much on who the decision-maker is, what decision you're trying to make, and who the effected people are by the decision.

Briefly discuss the role of uncertainty. In NRC's decision, first I would note that uncertainty and variability, which people like to distinguish. They are -- I won't say -- they're somewhat more phenomenal concepts, but they can get confused very easily.

But they -- both of those things do effect your decision, the decision that you make.

We treat both uncertainty and variability, usually in a problemistic matter, but let me distinguish between the two of them.

I'm going to use a quote that I saw in a book, I know remember who it was attributed to, but it sounded a lot like Stan Kaplan, so I think I'll blame him.

We know that variability is a property of the system that is being analyzed, such as tossing a dice, or variations in how people respond to dose, from person to person or uncertainty is actually an attribute or a property of the analyst. It's not a property of the system.

It reflects the state of knowledge about something. It's a real -- quite a different concept, but they get melted and mixed quite quickly when they do these types of analyses.

Now, the decision that NRC has to consider -- I see Stan's raising his hand.

MR. KAPLAN: I just had a little additional --

MR. WITTMEYER: You certainly may, since I blamed you.

MR. KAPLAN: I was going to say, this being the cause of hundreds of years --

REPORTER: I can't hear you, I'm sorry.

MR. GARRICK: You've got to get to a mic.

MR. KAPLAN: Would you say the uncertainty of the property of the analyst, yes, but it doesn't reflect the personality of the analyst. That's with the whole issue between the basins and the statisticians for the last few hundreds of years. Our ability is subject to -- so we're saying, uncertainty is a property really of the evidence that you have. It's a property of the hypothesis and the evidence that you have in front of you.

MR. WITTMEYER: That's a good distinction to us.

MR. KAPLAN: Not personally.

MR. WITTMEYER: Right. The decision that NRC has --

MR. GARRICK: You took that personally, didn't you?

MR. WITTMEYER: Never accuse Stan of being uncertain.

The decision for NRC is really quite simple. To either reject or accept an application or a licensed application construct and offer it a hot oil waste repository at Yucca Mountain.

Now, let's look for segment of risks that NRC faces as a decision-maker, and then how uncertainty comes in and effects that.

One risk is the failure to reject the application when the repository does not protect public health, safety and environment.

The other side of the coin is that NRC may fail to approve the application when the repository does indeed protect public health and safety and the environment. I'm going to tie those somewhat to what we originally called Type 1 and Type 2 errors in statistical hypothesis testing. Although, you need to be a little bit careful when you do this, because it all depends on how you pose your know hypothesis. But I'll probably use that terminology.

And just to define things a little bit better. When I talk about protection, I am talking about whether or not the repository poses or does not pose a risk to public health and safety and the environment. Those are different risks there.

Go to the next page here. Now, one of the requirements that DOE must meet, and this is just one of them. They must demonstrate the expected annual dose to an average member of the critical group and shall not exceed 0.25 mSv at any time during the first 10,000 years after permanent closure.

There's also a requirement how DOE shall demonstrate this one requirement, that we use in performance assessment, that accounts for uncertainty and variability in parameter values and considers alternative conceptual models of the repository system.

Moreover, there's a second requirement to help bolster this, and it keeps -- this really keeps with NRC's requirements or philosophy of defense and depth that DOE must also demonstrate that the repository includes a system of multiple barriers, including at least one engineered barrier, and one natural barrier.

Now, how does uncertainty affect this. If uncertainty is small, then we can estimate the risk to human health and safety and the environment quite accurately, okay. And the likelihood of making an incorrect decision is reduced. I mean, that's sort of common sense. If you know exactly what the risk is, then you can make the right decision quite readily.

Where uncertainty is great, the regulator has to be very careful that if we make the correct decision. And again, I distinguish here more clearly the two types of decisions that we don't want to make. That's the Type 1 error, I'll call it, and the Type 2 error, failure to reject a bad place, a bad repository; failure to accept a good repository.

Now, one of these are, you know, two sides of the same coin. If you use conservatism to reduce the likelihood of making a Type 1 error, that is, failing to reject a bad site, you naturally increase the odds that you will -- that you will not accept a good repository. This is sort of the thing that you probably learned if you were in quality control 20 years ago, or you look operating characteristic curve between a supplier's curve and a procurer's curve, in making a decision to accept or reject material that was being provided.

MR. GARRICK: Gordon, I just would like to talk about another point that's important in quantifying or in communicating about risk and uncertainty.

You imply with that slide that when the risk iks small or the uncertainty is small, it's accurate. And when the risk is large or the probability of distributions, that it's not accurate. You don't say that, but you say accurate for the small.

And the way a risk analyst thinks is, that in both cases, they're accurate. You have -- if you have quantified the risk and it happens to be large, and it characterizes the state of knowledge of -- and the -- and represents the evidence produced, it's just as accurate, in terms of quantifying the risk, as is the tightly bounded case, and that's a very important point, in terms of the language of the business.

And so when we talk about quantifying risk, what we mean is, expressing on the basis of all the evidence that you have, your total knowledge about a particular parameter and whether that happens to have a narrow distribution, or a wide distribution, they're both equally accurate.

MR. WITTMEYER: Well, you're basing your measure of risk simply on the central tendency.

MR. GARRICK: No, I'm basing the risk on the whole curve.

MR. WITTMEYER: Okay.

MR. GARRICK: And I'm saying, when I quantified the risk, I don't care whether it's narrow or wide, I've quantified it. They're both quantitative expressions of the risk.

MR. WITTMEYER: And you do not see any difference in how it affects your -- the likelihood of making the correct decision?

MR. GARRICK: I'd say it's a tremendous difference in how it effects the decision.

MR. WITTMEYER: Okay.

MR. GARRICK: Because I could have, for example, two possible situations of both having the same 10th century parameter, but one having a much tighter distribution than the other one and the decision is obvious.

MR. WITTMEYER: And that's what I'm really focusing on there.

MR. GARRICK: Yeah.

MR. WITTMEYER: Is where you have overlap of --

MR. GARRICK: But they're both quantified. They're both accurate.

MR. WITTMEYER: Okay. I agree. They're both accurate.

MR. GARRICK: Yeah.

MR. WITTMEYER: But I think your ability to separate to clearly identify what's -- when you are making a correct decision --

MR. GARRICK: Yes.

MR. WITTMEYER: -- becomes more troublesome the greater the uncertainty is.

MR. GARRICK: Yes.

MR. WITTMEYER: Let's talk a little bit more about uncertainty here and where you can use uncertainty.

For some reason, my right pointing arrows become downward pointing arrows, but we can invoke conservatism at several stages on decision-making process.

One, called the pessimistic PA where you actually don't propagate your true state of knowledge if you want to use that word or true state of lack of knowledge or uncertainty into the performance assessment.

You actually use conservative values, and things that tend to under estimate the ability of the repository to protect public health, safety and the environmental. Or you can use a more realistic approach, where you try and propagate the true state of knowledge that you have about a parameter or a process through the entire performance assessment.

And then you apply conservatism, kind of upistiliority (phon.) before you decide to whether to construct or not. And it's two different ways of doing it.

Moreover, I'll add at the end, because uncertainty may be large, the multiple barriers requirement is imposed, and that adds an additional degree of upistiliority conservatism to the decision making process.

Now, the next page, there's a little more discussion about conservatism and multiple barriers using a diagram that, in this particular format, I think Joe Holonich presented a number of years ago, or just a year ago at the end of the ERV. But it really looks very much like a hazard curve, although they're blocked out here separately.

Along one axis, I have listed increasing public hazard, that's the XX, as the YX is increasing uncertainty. And then the arrow that's drawn diagonally out from the origin at a 45 degree angle, sort of shows you the increase need for conservatism.

You get to a point where you have very high uncertainty and high public hazard, so that the risks you take, a product of those two conceptual things, and you have higher risks associated there. You may want to increase the need for multiple barriers or some sort of defense in depth.

I've put some things on there to give you an idea what -- where different facilities might lie. Some of these came directly off Joe Holonich's presentation. I know people will differ where these things are placed.

But, for example, I think that we probably know more about how a power reactor would operate. We have a greater degree of knowledge than we would for a high level waste repository. But the public hazard from something like a power reactor is probably considerably greater, than that posed by deep geologic repository. And I put some other things on here as well.

Smoke detector having a small amount of, I guess, amairicm of some isotope in it, poses a very small public hazard, we probably know quite well what mechanisms may lead to its release and uptake by people.

As we stage out here, these -- the bars, let me see if I can -- maybe I can use this to point, sort of shows the things in this area, you probably don't have a real high level need for defense and depth.

As you go further out along here, you need to use increasing levels of defense and depth in this area. Greater conservatism, if you will.

I'm just going to summarize here and then hopefully, there will be a state of questions. We expect the or I should say the NRC expects that the applicant will make a very strong effort to accurately quantify uncertainty and variability in their risk assessment. They have to really justify their use of parameter distributions that are reflective of both those different types of variability and the output.

And NRC expects the applicant to define where the uncertainties are very large in the risk assessment, and what measures have been taken or need to be taken to compensate for them.

And that's the end of the philosophy lesson. I'm learning as much from you during this as I'm sure you're learning from me, but --

MR. GARRICK: All right. George, have you got any questions?

MR. HORNBERGER: Gordon, on your slide five, you say that conservatism can be invoked at various stages, and you talk about the pessimistic PA versus the realistic PA. You started out by saying that really the treatment of uncertainty is through the analysis and we'd like to think that what we're doing is using the state of our knowledge, and the uncertainty reflects the, in part, the state of our knowledge and in some sense, the inadequacies of the state of our knowledge.

It's never been clear to me how one justifies your pessimistic PA case on those grounds. Because how are we using our -- the state of our knowledge, if what we're doing is propagating or not propagating our knowledge, but just using the pessimistic PA?

MR. WITTMEYER: Well, it depends on what stage of a project you're in in many times. I mean, you might use a pessimistic PA at a very recognizance level. Do you even need to be concerned about something.

If I think about the worst things that could happen, and I'm way before doing a design, this gives me an idea of what level of concern I need to have, and how much more information I need to gather.

So when you finally get to the point of doing a full fledged analysis, and you're pretty well along on developing a design for a repository, I'd think you'd want to definitely turn to doing more realistic PA.

But somebody correct me if I'm wrong here, but I think in probably decommissioning the area of decommissioning, we use one code that uses a screening approach. And that might -- you might term that a pessimistic PA.

Well, if you use that pessimistic values and it's not a problem, perhaps you can dismiss that and not do a lot of further analysis. On the other hand, if you have real concerns, then you better get in there and refine it, and be -- you know, improves your state of knowledge. And propagate estimates of true uncertainty as I put it in here, through the performance assessment.

MR. GARRICK: Yeah. I think the problem here again is language and I think conceptual meaning. I think that there's nothing wrong with pessimistic calculations and bounding analyses and conservative calculations. I think the only thing that some of us in the business are a little sensitive to, is referring to a risk assessment as conservative or non-conservative.

Because, by definition, risk assessment is supposed to be a realistic assessment of your state of knowledge about something.

MR. WITTMEYER: Uh-huh.

MR. GARRICK: And the issue of conservatism and non-conservatism comes later. The risk assessment provides the reference or the base line against which you make decisions as to how -- and that you're able to measure how conservative you are.

So, I think in that sense, it's a bit of an oxymoron for us to think in terms of a conservative risk assessment. It just doesn't quite make sense.

MR. WITTMEYER: I agree with you completely actually. I prefer that the risk assessment be done accurately, but whatever the decision maker chooses to do, he may use the information from the risk assessment and some other material that he hasn't included in reaching his decision. That's where, if conservatism is to be invoked, I would expect it to be invoked at that point.

MR. GARRICK: Yeah. And I think the way most of us have gotten around that, is to -- those of us that tend to be purists on this, is that we identify what we do as quantitative risk assessment.

MR. WITTMEYER: Okay.

MR. GARRICK: To indicate that we've quantified the uncertainties. And if you quantify the uncertainties, the only sensible way to quantify uncertainties, is to do it in terms of what you -- what the -- what's your -- what the evidence can support.

And so that moves you in the direction of a realistic model, but a model that gives you a full view of your lack of confidence, if you wish.

Ray?

MR. WYMER: I have an observation and a question. The observation is, like so many things that are sort of philosophical in nature, the words you used, a great many of us recognize these things intuitively without really articulating them. That's the observation.

And then the question is, how do you use these philosophical or intuitive things directly and meaningful in this work? What input does it make?

MR. WITTMEYER: Well, I mean, what it means is that -- I think this is the bottom line from all this presentation, I'll tell you what we like to do in our performance assessments, and this puts in on the bottom line.

We like to accurately reflect our state of knowledge about something in the performance assessment. Whether we have a great deal of certainty servitude or we have very little, that's the practical implementation.

We'll also use caution that we don't allow cases where people allow a great deal of uncertainty to, in a way, elude the actual risk posed by a repository system.

I'll give you an example that my boss gave me about Budda Sagar at Hampford. People's degree of knowledge about when waste packages might fail, had a great effect on, I guess I'll say the peak release at that time. If you assume that they fail over a long period of time, in effect, you're spreading out the mass release over a long period of time.

If you're concerned about the earliest time of release, well, that doesn't dilute the risk, if that is indeed the measure of risk. If it's -- if what matters is the height of that curve, how much mass is released at a certain time, then in fact, you would --

MR. WYMER: My thrust of that question was more direct use. Do you look at all this stuff and then make a pronouncement one day that you're making a Type 1 error? Just -- how do you do this?

MR. WITTMEYER: Oh, okay. No. I think what we do, is we do the analysis and, you know, so that we can preclude against making -- we don't want to make either type of error, right. But you'd guard on the side of trying to preclude making a Type 1 error. That, I think, is probably the greatest -- the riskiest for the decision maker. But I feel I'm still not answering your question.

MR. WYMER: Well, I'm not sure that you --

MR. GARRICK: Let me -- let me just quickly take a crack at it. I think the way I tried to answer similar questions, is to pretty much dodge it by saying, the risk analyst calculates the risk. He doesn't make the decision.

And also a risk assessment is not a decision analysis. Now, risk assessment techniques are employed in decision analysis, but there are other attributes that enter into the decision making process, such as societal benefits, costs and what have you.

So it's just part of the evidence for -- to put in front of the decision maker, which may be the citizenry for making a decision. But if -- it turns out, in most cases, to be enormously beneficial, in terms of the amount of evidence it captures, and the basis and the format that it's in, gives you some specific reference to working at.

So a risk analyst is not in the business of making decisions. He's in the business of analyzing the risk. But he's -- he has a responsibility to present that risk in a form that enhances the decision making process that will include other considerations.

MR. WYMER: I think I understand that. What I was thinking was, directly from what you've presented, I would say one of the ways you could use it, maybe the only way I could see you could use it, is you stand before the public and say, we are working very hard not to make any Type 1 or Type 2 errors. That's about what you've been --

MR. GARRICK: Well, I think the aspect that we're really looking for here, Ray, is quantification.

MR. WYMER: Right.

MR. GARRICK: And --

MR. WYMER: That isn't what you addressed.

MR. GARRICK: Yeah.

MR. WYMER: Particularly.

MR. WITTMEYER: No. I didn't really go into detail on quantification. I think the presentations probably that follow may talk more about that, some of the earlier discussions.

MR. WYMER: I'm ragging you a little.

MR. WITTMEYER: That's fine. I mean, that's --

MR. GARRICK: Milt?

MR. LEVENSON: Yeah. I have -- for different reasons than John's, I object to the use of the pessimistic and conservative analysis, because I think they are very, very unfair to the decision maker.

I was once a decision maker and if somebody gave me a pessimistic or a conservative analysis, my first question was, is it conservative of a factor of 2, by a factor of 10, or by a factor of 10 to the 4th. And if you can't tell how pessimistic or conservative it is, and generally you can't in the way you're doing things, then I think it is very destructive, rather than informative, that in fact, on a completely a different subject.

There's a Commission paper, SECY 00-70, control of solid materials with the staff has been instructed to determine how conservative are the conservative estimates. Which really brings it to the point that for a decision maker to tell him it's conservative, when he has to consider other factors, and he does not know it's conservative by 2 to 10 or 10 to the 4th, it's not a very useful thing.

MR. WITTMEYER: I agree with you. And I guess it's what Dr. Garrick said about the role of the risk analyst, is probably to give the best estimate of risk that he can, and the decision maker should use that information and whatever else he needs to, to come upon a conclusion.

MR. GARRICK: Andy?

MR. CAMPBELL: A couple of questions. In the beginning of your presentation, you talked about how uncertainty and variability and distinguish those.

How do you distinguish those through the model? How do you reflect those differences that we usually lump together in this Monte Carlo-type of an analysis? How do you distinguish that in the model?

MR. WITTMEYER: We don't make a great deal of effort to distinguish this of output from the code. If you'll look through the input, you can often -- you can tell what -- whether it's uncertainty about the true parameter value, or if it's actual variability, and you have a good knowledge of what that -- how you describe that variability.

We haven't made a real extreme effort to propagate those two types of still-castic effects separately and separate them out. They both play into effecting the bottom line risk value in very much the same way, effecting the bottom line number.

MR. CAMPBELL: So do you need to separate them out or do you feel that that's not necessary?

MR. WITTMEYER: Well, that's a philosophical thing. I have seen various risk analysts who say, yes, you must. In fact, I think that EPA requires in doing exposure analyses to make some effort to do that. Other risk analysts I've seen say no. Often times, you have attended uncertainties with describing variability itself.

So it's -- and I'm making a very clear

philosophical distinction in practice, it gets to be a little more difficult in times.

MR. CAMPBELL: You have eluded to it, is a number of cases, the model and the TPA Code, and TSPA, they may do similar things. You have proxy representations of processes. You're not actually modeling an actual process. But you have, you know, kind of a numerical value selected between, you know, some low value and some high value as a proxy for a process.

MR. WITTMEYER: Uh-huh.

MR. CAMPBELL: But when you propagate the uncertainty in that, you're not really propagating. I think this gets to one of Rod's issues. You're not really propagating the uncertainty in modeling, you know, the natural world or this engineered barrier. You're really propagating the uncertainty in this distribution.

MR. WITTMEYER: In some cases, I don't care. You talk about crane failures. I could model mechanistically all the physical effects that cause a crane to fail, to propagate uncertainty through that in doing very quantitative analysis, a still castic approach, or I could simply take actuarial data, preconceived crane failure, non-mechanistic. Hopefully, I'd be able to propagate the same information. I have the same uncertainty being propagated with more variability actually in the one case, propagating through. I think I've given you a good philosophical answer, but I'll let you ask me again if I didn't answer it right.

MR. GARRICK: You're absolutely right, Andy, it's a big subject that information uncertainty versus modeling uncertainty. And maybe we'll have a workshop on that some day.

MR. CAMPBELL: Okay.

MR. GARRICK: Jim?

MR. CLARK: No questions.

MR. GARRICK: Rod?

MR. EWING: I'll pass for the moment.

MR. GARRICK: All right. Okay. Thanks very much, Gordon. Tim, it's up to you to get us out of here at 12:30 for lunch.

MR. MCCARTIN: We're concluded. Okay. I'll try to wrap things up in a relatively short order, in talking about how we're going to use TPA Code and regulatory reviews.

Let me just right go to the role of the performance assessment of the code.

Once again, we have an independent approach to review DOE's TSPA. And there's really two ways we're going to review things. There's a proactive way and a reactive way.

And the proactive way, both licensing and prelicensing, we can risk inform what we're doing. We have the development of the review plan, development of analytical tools. You'll see later, either today or tomorrow, the Center's working on confrontational approaches for coupled processes, work with multi-flow, et cetera.

Why are we working on those particular tools? Well, obviously, there's something about either the chemistry, the thermal aspect that we think are -- is important enough when we look at our performance assessment, also DOE's, that we want to have some approach for evaluating things in detail.

In terms of confirmatory testing. There are certain things that you'll see I believe, either Wednesday or Thursday, some of the laboratory work, and obviously, why do we do a particular confirmatory test? Well, we think they're specific aspects of the performance that we think are important. A lot of that's based on our TPA calculations.

Then there's the reactive side of it. We want to be able to probe DOE's analyses. They're going to come in with a performance assessment, this is our approach, our tool to try to take apart the DOE's assumptions and verify our understanding of what's going on.

And with that, I'll go to a set of specific examples. The first is, confirmatory calculations. DOE's going to have a performance assessment that does overall performance, human intrusion and the capabilities of the barriers.

In the proactive sense, obviously, we have, as you saw, today we've done an independent calculations of what are the important barriers. What are the capabilities? What's going on with those particular capabilities? What's supporting them? What are the important and intermediate results to look at, et cetera?

Reactively, I think DOE is going to have their performance assessment. They're going to have assertions about what they believe the barrier capability is. We need to go in and possibly use our code to modify it to the parameters they're using or tweak our models, hopefully.

We'll do some confirmatory tests that, gee, why don't we see, as was brought up earlier with the neutralization analysis that DOE does, where they see approximately at times, almost a two ram dose. We don't see a similar thing when the waste package fails, in our barrier controloziation.

And as was brought up, once DOE's analyses, when they fail a barrier, the waste package, they lose their credit for the clatting. We haven't taken credit for clatting, so it doesn't have as dramatic of an effect.

But there are reasons for that, but we want to use the TPA Code to look at the capabilities of barriers.

Next, as we've talked about, conservative/bounding calculations and I guess there is that dilemma with what exactly is considered a calculation, what exactly is a bounding. But we expect that DOE, in the performance assessment, will in certain areas, potentially where there's a lot of uncertainty, rather than collect a lot more data, try to defend a particular approach, they may say, we're going to take a conservative approach here.

React -- that's a reactive aspect for our review. We would like to use the code to evaluate the degree of conservatism. What exactly does this mean? They said this is conservatism, is it? Isn't it? We can look at different approaches in our code, et cetera.

And one of the things I know that the committee has brought up, you may claim conservatism for a particular aspect of performance, be it gee, we'll assume I'll make a very simple analogy, but I'll assume the temperature is always above boiling. It's very conservative for my release model, which is temperature dependent, and so I will assume it is always above boiling. It's conservative for that particular realist model, but then if you also carry that through, and you never see any water coming into contact with waste, or in terms of overall performance, one could question whether that truly is a conservative approach in terms of the overall performance assessment.

Clearly, it will not be that clear cut, but we will have to analyze things to make sure that indeed, conservative assumptions are confirmed with respect to the overall performance measure of dose. In this area, it's certainly possible that we can use DTO process models in addition to the TPA Code.

As you saw today, we used the code to look at sensitivities and uncertainties in the code. And the performance assessment code is a very complicated model. There's a lot of parameters.

I know Dave Esh asked me to make a statement and it's true, that even though our TPA Code is simple in respects to the real system, we have spent a lot of time and all the technical disciplines have contributed to each of the modules. And a lot of thinking and effort have gone in. These models, while being simple in nature and computational requirements, incorporate a lot of thinking that is brought into the development. It's interesting that when you do the performance assessment overall, you find that there aren't that many things that it's really that sensitive to.

There are some particular aspects of performance that dominate the calculation of overall performance.

In a proactive sense, clearly, we've been doing our sensitivity analyses, to look at what's important. I think that's important, both licensing and pre-licensing.

When we go to these KTI meetings for issuer resolution, we look at some of -- in some of the KTI's. We look at well, do we really need to know this information, how important is it to us? How important is it in our calculation? How important is it in the DOE calculation?

You don't want to sit there and put demands on learning information that isn't going to have a significant impact on performance. And then ultimately, in the reactive sense, we want to understand, well, why does DOE have such importance to the waste package failure in their neutralization analyses. As we've talked about, I think it's the clatting credit and the diffusional release.

But there's -- we want to look at things, and react in terms of being able to use our code to analyze these types of things.

And also, in the reactive sense, I have the performance confirmation program. Certainly understanding, what are the important grammars and variables that should feed into performance confirmation. What do we think are the candidates that DOE should be looking at, when they design their performance confirmation program.

Integration and coupling of processes and models. Once again, the DOE performance assessment is required to include those features, events, and processes that are going to effect performance.

That includes coupled processes. In a proactive sense, we're looking at the types of things, the chemistry is very important to us, in terms -- and the temperature, in terms of the release rates. Generally, we're doing detailed process models, as I indicated, in trying to incorporate the effects as needed into the TPA Code, but it's very important to make sure that all the appropriate degradation mechanisms are considered by the DOE.

Certainly in the reactive sense, we're not expecting DOE to include all coupled processes, all phenomena. There will be things that will be screened out, we'll need to verify their assertions. We did not include this particular process, this particular coupling for these reasons.

We'll use, I believe, a combination of the TPA Code, in addition to detailed process models, to help us decide whether we agree with the DOE assertions.

Evaluation of uncertainty. Once again, DOE's performance assessment is required to evaluate uncertainty in the calculative, proactively. As you've seen, we're looking at uncertainty. It's an independent calculation; looking for timing, magnitude of the doses.

In our code, we have a variety of different models and assumptions we can use, be it the chemistry, the reflux, the saturated zone, the flow field, release rates. There are many different combinations that we can test to see if we're -- what seems to be effecting the performance the most.

Reactively, we'll look at how DOE has estimated overall performance, what they've included in their calculation, including subsystem performance, to see if they captured the uncertainty inherent in their calculation.

There's also the issue of completeness in any performance assessment. Do you have everything you need to have? Proactively, once again, we're looking at the effects, and looking how that effects the dose, et cetera.

Alternative assumptions. Once again, DOE reactively, they will certainly screen out particular FEP's, some will be screened out because they don't have a significant effect on performance.

We'll have the ability in our code, hopefully, to capture some of these, and verify at least with our code, does it truly not have a significant impact. And our code is another vehicle for looking at the impact of some of these things that have been excluded from the analyses.

And, you know, in summary, our applications are both proactively and reactively to what's going on. We have a variety of quantitative evaluations, as I indicated. I think we need to -- I think Dave Esh's words were or a nice way of saying, tear apart the DOE analyses, the code gives us that ability. And I realize I think one of the things brought up, clearly, if you don't have it in your total system code, it's hard to get sensitivity to it.

And you know, clearly we agree with that, but I think you'll see from some of the presentations later on the program with coupled processes, we are looking at some of these difficult aspects of the repository, be it the chemistry, be it the non-exothermal flow to get a sense of -- trying to get our hands around the uncertainty, where could we be wrong; what could be its impact.

And that's very important. I think those off-line analyses are just as important as the overall PA. You need to understand what you've got included, what it's potential impact is, and certainly when we talk about TPA, we talk about not only the code itself, the supporting bases, and these other process models that are used to assist.

With that, I'll stop. I'll be happy to answer any questions.

MR. GARRICK: Okay. Committee, any questions?

MR. LEVENSON: I have one. Just to protect my reputation, too.

MR. MCCARTIN: I'd be disappointed if you didn't have any questions.

MR. LEVENSON: You've emphasized the importance of treating the uncertainties when you do the assessments or evaluations. How do you treat generally an uncertainty of a best estimate is more or less symmetric about the value?

How do you differentiate, in how you treat an uncertainty around the best estimate, compared to the uncertainty around a conservative or pessimistic estimate, where the only uncertainty is entirely on the safe side, therefore has a different connotation?

MR. MCCARTIN: Well, there's certainly the --

we hope -- we try to be realistic in most cases. There are some areas where --

MR. LEVENSON: But you're assessing somebody else's work?

MR. MCCARTIN: Sure. Sure. And most likely in the DOE analysis, the lower speed conditions that could be a little worse and things that could be better. Be it, alternative conceptual models, et cetera.

And I think it gets to the use of alternative models, more so than a little jiggle around parameter, what if conditions are much different and some of the one-off analyses and the neutralization analyses -- well, not neutralization, degradation under performance analyses that Dave was talking about.

But I think you try to get a sense of what if we're wrong in particular areas. But you're right. In some areas, if "no credit is taken," then there really isn't anything worse, per se. You need to be certain that it isn't detracting from something else. I don't know if that answers you.

MR. LEVENSON: Your comment was, it's fairly important that you assess the uncertainty in the DOE estimates. What I'm saying is, that becomes complex, unless you had some idea as to what conservative or pessimistic estimate is.

From the first principles, if somebody gives you a value and say, well, it couldn't have measured that to better than plus or minus 50 percent, that's the uncertainty. But if they think of a measuring value and multiplied it by four to use it in the analysis, --

MR. MCCARTIN: I see, yeah.

MR. LEVENSON: -- that, if you attribute an uncertainty to that, you're doing a disservice.

MR. MCCARTIN: Yeah. Yeah. You're right. It's a complicated process, in terms of trying to get your hands around it.

I still believe ultimately, you'll go to a simple set of, for lack of a better word, I'll say performance measures.

MR. LEVENSON: That's --

MR. MCCARTIN: Well, how much infiltration is getting down, how many waste packages are getting wet, and I would prefer to -- well, let's -- I think current estimates I think DOE has 11 percent, I'll say of waste packages experiencing drips. Why do I believe that? What kind of assumptions are tied to that? Could it be twice that? Could it be much less than that? And try to get a handle on some of those intermediate outputs going down the system.

MR. GARRICK: I think we're going to have to move on. Are there any other questions from the committee?

MR. WYMER: I have one.

MR. GARRICK: Okay.

MR. WYMER: Do you have any sort of general framework or methodology or a set of criteria for which you can evaluate DOE's uncertainty analysis with respect to the propagation throughout the entire system?

MR. MCCARTIN: Well, we're looking at in developing some procedures for the review plan that we've talked to. What kinds of things we need to in reviewing. It's still at an early stage. Other than -- we need to understand what their uncertainty represents; be it the parameters, be it conceptual models, and how they've accounted for it.

MR. WYMER: That's sort of an internalist, the overall approach.

MR. MCCARTIN: Well --

MR. WYMER: The thought that occurs to me, is that there's an unevenness in the uncertainty, in the various stages of the model. And in some cases, they're introduced deliberately, in other cases, they're bedded in the data, and other cases, they're kind of guessed at.

MR. MCCARTIN: Sure. Yeah. Yeah.

MR. GARRICK: So an uncertainty tracking

scheme.

MR. MCCARTIN: Yeah, right. That's interesting. That's an interesting thought. I'm not aware that we've gone down that path to try to bend the uncertainties, if you will. Here's an uncertainty that they've done for -- they simply reasons of conceptual modeling uncertainty versus they elected to be conservative versus a parameter. We haven't --

MR. GARRICK: Consultants, any questions?

MR. CLARK: Just a quick one. This reflects more than a little personal bias, but I think you're -- I think we have a little bit of a difficult situation, in that you're running a model, and you're relying on other people for the data. Are you comfortable you've got a real good communication there, your folks? And I'm a firm believer than the modeler actually even gets the data, if that's possible. Is that a concern to you at all?

MR. MCCARTIN: Well, I guess you'd always, as a person making a model, you'd always like to have some data collection on your side.

MR. CLARK: I know, but are your folks out there in the field?

MR. MCCARTIN: Oh, absolutely.

MR. CLARK: Okay.

MR. MCCARTIN: I mean, the job is really -- DOE has the budget to develop the characterization and the technical basis supporting the models. And certainly between NRC and Center staff, we have Appendix 7 means, where we go out and look at what's being done.

MR. CLARK: There's no substitute for that.

MR. MCCARTIN: Oh, absolutely. There's been a lot of visits by NRC Center staff to various laboratories, to Yucca Mountain. And in certain particular areas, we actually have gotten core samples, et cetera, that the Center does some laboratory work.

In previous years, when the research budget was a little higher at NRC, there was field work done on natural analogs, et cetera. But generally, we rely on DOE.

MR. CLARK: Okay. I don't want to belabor that. I just wanted to raise that.

MR. GARRICK: Good point. Andy? I want to thank the speakers today. It was a lot of ground to cover. We've got to decide what we want to do with it, but we appreciate the effort that we're all going through.

I think now, unless there's some a question on the prior, somebody, that they'd like to raise at this point, we will adjourn for lunch and expect everybody back here at 1:35 by that clock.

(Lunch recess.)

MR. GARRICK: The meeting will come to order. The next topic on our agenda is preclosure safety analysis tool, and to lead us through, from a member standpoint, this discussion will be Milt Levenson.

MR. LEVENSON: Thank you, John. It seems to me that the people doing this have really an easier job than the people we heard this morning and yesterday. You don't have the uncertainties of 10,000 or 100,000 years. You can only deal with the certainties in the next 100 years, which should make it somewhat easier maybe.

I think I personally view this as really consisting of two parts. And I've been hearing how they're treated, in a sense that the -- essentially everything that's above ground, at the repository, has been done elsewhere before; the handling of fuel, whether it's loading dry cast or pools or unloading reactor containers of all kinds. The low ground activities are new, first of a kind. And I hope during the -- some time during the first couple of these presentations, we will understand whether some of the experience in the past has been blended in to this package for this new undertaking.

With that -- can you hear us? Can you hear us?

MR. JAGANNATH: Yes.

MR. LEVENSON: The floor is all yours.

(Reporter's Note: Speaker has accent that is indiscernible at times.)

MR. JAGANNATH: Good afternoon. I'm Banad Jagannath from the (indiscernible). I'll briefly present an overview and status of the preclosure safety analysis tool, which we're working on.

At this point, I would like to acknowledge the preclosure team here, consists of Mr. Nataraja, Dancer, Ahn, Galvin and Johnson.

A brief overview of the presentation. Basically I will set up the background and give you basis of doing the preclosure safety analysis, and part of the tool that is part of that -- the actual presentation of the tool were done by --

First I'll talk about the focus on NRC review. What would be the basis of the review safety analysis and then we'll talk about the level of risk.

(Indiscernible) contrary to reactor (indiscernible). I'll talk about the preclosure safety analysis required for the regulations, and what NRC review and then (indiscernible) is expected to (indiscernible) and how they're going about it.

The focus of the NRC review is basically based on directions from the Commission, (indiscernible) and the strategy plan of the (indiscernible) performance based.

(Indiscernible) regulation, particularly the (indiscernible) complying with performance requirements, (indiscernible) in 63. (indiscernible).

The NRC performs a pre-safety (indiscernible) of the site structures, facility hazards (indiscernible) and lately even consequences. In demonstrating the safety case.

So (indiscernible) the list components and the consequent components, and performance of those as (indiscernible) the perform base regulation.

NRC, we look into these things from the same prospective, and they're looking at what they've done in demonstrating the safety case.

NRC's purpose will be basically learning how DOE (indiscernible) the structures, systems, and components that are (indiscernible) safety in the safety case. And (indiscernible) is part of the safety review, to look at the design and other things for (indiscernible) the (indiscernible) -- in this renovation.

The next one is a slide on the level of risk, compared to a (indiscernible) --

(Indiscernible)

NRC, in their review, ... perform .... focus of these .... how we the important components, and we may do focus and .... studies to go deep into that. ... analyses to check the ... is correct. ... focus review for DOE's work. DOE has to make a case and we ... that.

NRC duty review. We are developing a software base to .... This is basically to help NRC ... work. ... the tool has a lot of ... Each ... represents the components which are listed in the safety analysis like a slide ... structure, hazards, ... scenarios, or those types of information. Each of those have components. ... the next presentation ... that. The ... had authority to ... look at the portion of the DOE's analyses, using any margins they want, to be able to extract ... from that ... module to see whether DOE's performing adequate analyses, ...

Also, this is like a ... thing. Most of the ... tool. And that can be used later on by the staff in ... because when you have ... based on any subject, the ... and those conclusions are ...

So when it's ... to ... we can extract them from that. It's just a bookkeeping function of this one.

Actual tool and it's used .... by Dr. Dasgupta, will be the next presentation. This is an introduction of the ...

MR. LEVENSON: Thank you. John, do you have any questions?

MR. GARRICK: I don't think so. I think maybe in the next section maybe.

MR. LEVENSON: I have a couple, which are a matter of scoping. Where does the preclosure safety analysis start? What I mean by that is, the fuel is being shipped, it arrives on site, it's unloaded, then it moves into the facility. When -- where does this program start being responsible for safety?

MR. JAGANNATH: When it comes to the site, from that point onwards, the ... project, and the safety of ...

MR. LEVENSON: So as soon as the fuel arrives on site, --

MR. JAGANNATH: On site.

MR. LEVENSON: Okay. Where --

MR. JAGANNATH: Yes?

MR. LEVENSON: Where does it end? Does it cover backfilling the repository at the end of the operational time, or does it just stop at the end of the operational time?

MR. JAGANNATH: ... by definition of preclosure ... starts. So when ... decides to close it, but operation ... in placing the waste, ... 25 or 30 years, and beyond that, exists a matter of DOE ... And the ... it can still be part of the very last item of the preclosure.

MR. LEVENSON: Okay. I think maybe we can just go on. Thank you. The next presentation, Dr. Dasgupta. Go ahead.

MR. DASGUPTA: I'm making a ... safety analysis to ... --

MR. LEVENSON: Well, introduce yourself for the court reporter.

MR. DASGUPTA: I'm base director from the Center, the Center of ... I'll be talking regarding the preclosure safety analysis tool, part two presentation.

First of all, I would like to think the team ... participated in this work, who are listed over here, and the people that ... at NRC.

The ... is Mr. ..., which consists of a brief overview of ... project, preclosure safety analysis methodology, tool demonstration, application of the tool, future work, and conclusion.

The ... demonstration that you see over here will be done tomorrow morning at 8:30 over here, so we would ... during this presentation here.

A brief overview of the operations of the YMP project. I would like to ... and walk through the operations of the project and then we will comment ...

This picture shows the design of the repository. The ... coming from the distant operations that ... north ... area, this is where the surface ... is, and then ... to the underground facility, where the ... is ...

In the north portal, this shows the north portal review ... The facility surface is ... in cast, --

(Indiscernible)

... the entire facility can be divided into several functional areas. For example, the ... or ... building will be one functional area. The underground testing ... function area, or it could be divided into processes, like ... to the transportation surface transportation or the underground transportation or the fire hazards, anything.

So that ... analyze. For example, over here we have listed ... operation in the risk handling building, in which we want the design informations, the process ..., the mechanical ... background, the description of the operations of that ... transfer system, we need to review that. And that information naturally goes down to this box over here down below.

Before that, we liked to identify the natural events and ... external events. These natural events are ... specificity with tornado, flood, and things like that. And the human ... external ... raised as the aircraft crash or ... from the nearby military facilities.

These hazard analysis -- these are all special subjects, and ... is going to provide the analysis for all these. These analysis are reviewed ... and only the information of the review information are put inside the tool, primarily the ... of the ... and towards the mitigating features that we have.

So this -- these are the information that are stored inside the tool.

The next process is identification of human induced internal events. Over here is primary ... the hazard analysis. .... description of -- based on information that we had accumulated from the canister transfer system. We did try to find out the sequence of operations. The equipment that are used in there, in that system, and the ..., that was to be passing through that area.

After that, we gave -- ... or analysis. And primarily to identify the ... that we see here, which means that the ... potential ... there's a potential of radiological dose release.

To help us do a ... that --

(Indiscernible)

MR. LEVENSON: One second, let me go back a minute.

MR. DASGUPTA: Sure.

MR. LEVENSON: The scenario assumption, you drop the fuel from one meter, and then the next thing we see is a consequence, 11 kilometers away. What are the mechanisms involved, what are the assumptions for ... term for releases? It sounds like you're assuming you dropped the fuel from one meter, it all splits wide open and all becomes airborne or something.

MR. DASGUPTA: No, I don't think it's a drop.

MR. LEVENSON: Well, what sort of tools are being used for this?

MR. DASGUPTA: ...

MR. BENKE: This is Roland Benke, from the Center of Consequence and Analysis.

What we did, is we used new Reg 15, 36 and 1567, to give us release fractions for impact rupture. So typically, something for particulates would be like two particles released in every million of this drop.

The release height is assumed to be one meter, let's say a canister on the ground; however, the drop height could've been higher. The assumption is that reach curves so that maybe, you know, the crane was at six meters or three meters, something like that.

MR. LEVENSON: So you mean this consequence doesn't follow from the scenario?

MR. BENKE: The release --

MR. LEVENSON: The scenario is one meter drop?

MR. BENKE: No, that's the release height. That's assuming that the Hepa vents from the waste handling building would be at a one meter height. It might not be realistic, but it's assumed for this example.

So if a stack is used, maybe the release height would be 10 meters or 20.

MR. LEVENSON: Oh. This isn't the drop?

MR. BENKE: Correct.

MR. LEVENSON: Because that -- what confused me is the term instantaneous release. Okay. So you're assuming the instant it's dropped, everything that comes out of it, is going out the stack?

MR. BENKE: Correct.

MR. LEVENSON: Is that what the word instantaneous means?

MR. BENKE: Yes.

MR. LEVENSON: Do you have any estimate as to what the conservatism is in that?

MR. BENKE: That kind of follows on to our future work, where we're be using Melcor code, to determine the amount of this release material from the canisters, and determine how long it takes for it to go through the ventilation system, and then how much is retained within the building, due to gravitational settling and et cetera. So more detail will be added at a later date.

MR. DASGUPTA: Yes. And over here, back to the future work, we would ... we would also the worker dose calculation. ... database, we would ... documents. And we would have interactions with DOE. So far we have very limited interactions with DOE, but it's been planned for the next year, February.

The conclusions from this topic is ... the tool is intended to assist the NRC to review DOE's ... safety analysis for the preconclusion period .... quickly and systematically to .... important to safety.

The tool is ... using visual ... and we have incorporated some ... in our software. The tool has the capability to perform safety analysis for the entire operations ... selected operations.

... talk here, so if you have questions, please ...

MR. WYMER: A couple of small things occur to me. I think they're safety related. I couldn't tell from the drawings, the plan of the facility, what about there's any surge capacity? By that, I mean there will be shipments coming in containers, but if something shuts down with respect to getting -- hitting the repository canister, then things will be stacking up.

Is there a place to put them?

MR. DASGUPTA: We, so far, from the design -- I think the information that .... so far what we had information were very little. And as you saw, the drawings that we have, is almost like cartoon drawings.

But to answer your question, we did not ... very large stacking of the material, but there will be ... stacked outside, and there are some ... for the canisters to be stacked inside, but we do not know what's the amount of those storage facilities.

MR. WYMER: Okay. There will be safety considerations associated with those.

MR. DASGUPTA: That's correct. And if -- I agree with you, and especially if there is aircraft crash probability is higher ... than it can ... for safety.

MR. WYMER: All right. My second point is, what about things like ventilation failure, especially associated with releases activity, and I didn't see that in there.

MR. DASGUPTA: Right. And I think they do have an escape for the ventilation, and I think fairly recent ... back shows that they have two or three levels of ventilation in the primary -- secondary levels.

The ventilation is -- they have -- you know, it's a differential pressure that it's been sucked inside the ... and then from there, it comes out of the heat pump.

MR. WYMER: And there's no pressure differential.

MR. DASGUPTA: Right.

MR. WYMER: Then unrelated to that, after the fuel shipments stop storage, there still is quite a while before closure.

MR. DASGUPTA: Correct.

MR. WYMER: Is it your responsibility to evaluate the safety of the ventilation system after storage is completed before closure?

MR. DASGUPTA: I think so. I have not gone that far to ... but if anyone can address that issue, yes.

MR. GARRICK: Well, certainly anything that's related to public health and safety would be an issue before us, ventilation --

MR. DASGUPTA: ...

MR. GARRICK: ... could some leakage from the waste package could get to -- that's an issue, and --

MR. WYMER: Yeah. The question is really, whether it's explicitly recognized in the safety analysis.

MR. GARRICK: Oh, yeah.

MR. LEVENSON: George? John?

MR. GARRICK: Yeah. The NRC has a legacy of safety analysis tools that go way back, and you know, from safety analysis reports to SER's to PRA, to integrated safety analysis, and probably others, and now this.

What's the difference between what you're trying to develop here, for example, and the integrated safety analysis method that they employ on such things as fuel cycle facilities, et cetera?

MR. DASGUPTA: Well, this methodology is no different than any other methodologies that you have seen that we have the same ... over here. And as you saw, we are using ...

MR. GARRICK: Right.

MR. DASGUPTA: ... has been used by PRA. But what we have tried to bring together in one place, under one umbrella, which we did not see. Say for example, as with ..., that using the same tool and the same file, we could keep -- be able to keep track of their facility. Either we do the safety analysis or DOE does, and we accept that, and we divide that into functional area, and then keep the information.

Now, this tool is not only for this coming license application, which is the construction authorization, which during this time, we will not have much to ..., but this tool is for way beyond that ... DOE is going to present again the safety analysis to .... possession of waste. And during that time, the design will be much more detailed, and a lot of information will be there.

So this tool keeps -- gives us a ... of the ... that means today while we are looking at the canister transfer system and we have ... and we find out that DOE has -- well, is going to take care of ... with certain safeguard, and that's why this event is no longer a ... event. We would then again check to ... the final design that such safeguards are in place ...

So this one gives -- it keeps track of the holding, so it's not just for this part of the license application ... it should be designed to take way beyond that.

MR. GARRICK: Yeah. Well, the question was, with all the safety analysis tools you have, and there's others like the PRA that's being done on dry storage facilities, I was just curious as to why there is a need for another one.

Is the strategy here the same as for the TPA, that is, to say have an independent safety analysis tool to independently check, if you wish, the results of DOE's PESCA?

MR. DASGUPTA: That's correct. I mean, we ... if we were required, we will do an independent analysis of that, that's correct. I mean, because this is a review tool. This is -- while reviewing, we may have to do the analysis. We might ... that their hazards are .... that they have identified all the hazards, we might want to do that.

If you're satisfied with that, we might just want to check into their .... or the sequence of events they have ... calculated or evaluated currently or not. And bringing all that together, but I believe -- I mean, we looked at and didn't find any tool that encompasses the entirety together, what -- this is, as you saw, there are different tools we brought together and put under one umbrella.

And it's just a bookkeeping and it's not any --

MR. GARRICK: Yeah. One of the things that I'm just curious and may be concerned about. Is this problem may be able -- you may be able to confine this problem to just a couple of operations with your cut-off criteria that you've adopted. And as you've already said, the canister is the biggest worry, the handling of the canister.

And I guess that the thing that one would wonder about here, is not over complicating it. It looks like a pretty simple analysis and the people aren't used to me saying this, but it would seem that abouting an analysis would eliminate most of the scenarios that you could imagine, except for maybe the on-site canister handling scenarios, or a few -- and even there, you could probably bound it.

And I'm very suspicious of this result at 11 kilometers. It seems like for a falling accident, that seems awfully high, especially given the results that I recall from the transportation studies at SanDio, where they literally beat up on containers and cast, and what have you, and hardly got any release, or never got any release from train crashes and truck crashes and what have you.

So I guess one of the things that it seems to me, is there might be an opportunity here to narrow that problem down to just a couple of scenarios. And I assume that if that's possible, that's something you'll do. It just doesn't seem like it's that big a deal.

MR. DASGUPTA: I agree with you, in some cases we could do that. But our problem is, when we get into the next phase, I think you will see a lot of details, and maybe we are preparing for the next phase of the analyses.

MR. GARRICK: Yeah. I'm sure you're aware of this, but one of the things you have to be a little concerned about when you assign cut-off frequencies, is how many scenarios you're going to end up with. Just pushing it to the limit, if you have 10 to the minus 6 cut-off and you have a million scenarios, you know, you're going to have an accident a year.

So these cut-off things on unbounded numbers of scenarios is something that you have to be very careful with. In a reactor, it's not uncommon to have a million scenarios, for example, you know, because of the combinations of permentations are really amplified because of all of the mitigation features that you have.

Now, in this case, you know, you're not talking about anything like that. But a 10 to the minus 6 cut-off criteria in a reactor, would be totally unacceptable. I expect here, it's probably okay.

MR. LEVENSON: Tim?

MR. MCCARTIN: Yeah. One quick thing, Dr. Dasgupta, and I would read generally the operations are -- seem to be relatively simple, and there should be a huge scenario that could capture how worried should we be.

However, as easily said, what -- over the last year or so, what we realized, is we really don't have -- haven't analyzed the problem to any degree of -- well, to any detail to allow us to really defend that gut feeling. And this is an attempt to -- to using other tools that are out there, but let's do a systematic look at this, and make sure that gut feeling is right.

And you want to make sure those cases where there possibly could be a fire or an explosion, what's going to happen, what could happen, and just systematically go through it, just to make sure.

MR. GARRICK: Yeah.

MR. PATRICK: If I could, Wes Patrick with the Center. Wes Patrick of the Center.

Just to clarify, there are a couple of things in these presentation that look like there's a slight misunderstanding.

The Sandia work, what I think you're referring to, Dr. Garrick, was cast --

MR. GARRICK: Yeah, I know.

MR. PATRICK: These were baskets of their fuel assemblies. So it's a very different thing, their fuel assemblies.

MR. GARRICK: Yeah.

MR. PATRICK: So it isn't like a fragile system.

MR. GARRICK: But the violence of the tests were ever so much greater, too, with 70 mile an hour train crashes and truck crashes.

MR. LEVENSON: Okay. I think that a couple of speakers ago, there was a discussion of the desirable philosophy of analysis. It seems to me, this is a very good one to start practicing that, and do only a best estimate analysis, rather than doing very pessimistic and ultra-conservative. Because unlike reactors, there's no issues of stored energy, there's no issues of sudden energy release. It's orders of magnitude differ from potential, and so I think that it's a good place to start doing only best estimate.

I'll ask one question on your slide 20, you identified continued development of failure rate database. What does that mean?

MR. DASGUPTA: This is equipment failure.

MR. LEVENSON: I know, yeah. But I mean --

MR. DASGUPTA: Well, we have started looking into different figure rates, because --

MR. LEVENSON: This is just collecting the data because --

MR. DASGUPTA: That's right.

MR. LEVENSON: -- the NRC has, you know, for the most of the things that are of interest to, crane failures, all of those sorts of things. There's a huge database that already exists.

MR. DASGUPTA: Right. And those are the ones that we're collecting. It's primarily based on the nuclear ... industries. But we also have to ... addressed your ... and we have not ... this stuff, but that is our next aim to see what happens underground. And we have to look into -- in the underground part of the transportation, we are looking at the mining. We are looking into the -- you know, the metro rail and what are the accident scenarios over there that would cause this sort of thing.

So we have to eventually ... as well. And we have to continue for those data in the next year.

MR. LEVENSON: I would hope in this nature of doing best estimates, you wouldn't just take mining data. I think --

MR. DASGUPTA: Yeah.

MR. LEVENSON: -- but actually experience of the Department of Energy shipping transportation system is significantly different than the trucking industry at large, because of all of the additional requirements, everything from training and equipment and safety. Of course, I would hope that --

MR. DASGUPTA: Sure, yes.

MR. LEVENSON: -- you similarly --

MR. DASGUPTA: Right. We --

MR. LEVENSON: -- strive for best --

MR. DASGUPTA: Sure.

MR. LEVENSON: Anyone else have any questions?

MR. GARRICK: John Larkins.

MR. LARKINS: Just for my information, one area where you can't potentially get a somewhat energetic release, would be fires, and the risk methods that are currently being used for reactors might not be totally applicable with these scenarios. Particularly if you have a canister that can break open and it could air oxidation, so that might be an area that you want to --

MR. LEVENSON: That's been looked at for dry cast storage?

MR. LARKINS: Not very well. Not very well. I don't think all these issues are totally addressed.

And I have a second question for information. On the decision on the performance objectives for SSC's, has that been already defined?

MR. DASGUPTA: No. I think that's the job of the next year or I think NRC's looking into that ... or, Tim, do you want to address that question?

MR. LARKINS: And we can talk about it off line to save time. You mentioned a decision on SSC's important safety, and performance objectives for those.

MR. MCCARTIN: Well, I assume, you know, those things that are needed to meet the performance objectives for preclosure are things that mesh. ... and now there are discussions, and I don't know if Raj wants to talk, that in terms of integrated QA and things of that issue that are ongoing with DOE.

MR. LARKINS: The last time we talked about it, if these were still being developed to discuss, and I was just curious as to whether or not some criteria performance objectives had been developed for those SSC's and safety.

MR. MCCARTIN: Other than what's --

MR. JAGANNATH: No. We are not developing any new criteria. Basically compliance with the ... and category of the ... based on the frequency to ... we had to make a decision on ... safety, ... in terms of those or in terms of frequency ..., ... to make sure that classification number is correct. But the decision ... we are not ... yet, but basically looking at the data, we ... systems are ... safety. If not ... if it is not function, we ... those ... pick it up. It's not final as yet, but we're working towards it.

MR. LEVENSON: Any other questions, comments? Back to you, John.

MR. GARRICK: Thank you. Yeah, you've done a wonderful job with that, and now I'm going to rule on that. Not really.

I wanted to announce that we're making an agenda change or a schedule change of the agenda for tomorrow. And you might want to make a note of it.

Because one of our members is having to leave earlier, we, through the cooperative effort of the Center and other presenters, we have moved the agenda item tomorrow that's labeled investigation and importance of coupled processes related to repository design to be first at 8:30, and it'll go from 8:30 to 10:00, and there will be a break from 10:00 to 10:15, and then from 10:15 on until noon, we'll have our tour.

So that also facilitates the court reporter requirement, because we only need the court reporter for these session -- the first session that'll go from 8:30 to 10:00. I hope that doesn't create any problems for others.

Okay. With that, we'll take our break.

(A break was held at this time.)

MR. GARRICK: This is going to be the sessions on alloy C-22 studies, and the chemist member of our committee will lead the discussions.

MR. WYMER: Well, we finally got now to the nitty gritty. Or at least the nitty.

And this afternoon we have two presentations, one from the Center and one by DOE, in that order. And there are two important features which I hope with respect to dwell on; one is the nature of the fabricated alloy that -- C-22 which goes in to making the outer layer of the waste package. And the second is the nature of the dissolving solutions, the corrosion -- discussed that's carried out, and what -- how suitable is J-13 as a material -- as the base solvent.

And finally, I hope something will be said about the need for a better understanding of the mechanisms of corrosion of C-22, which in my mind, is needed if we intend to make the great extrapolations that are necessary to go from 5, 10 or 20 years to 10,000 years with respect to the corrosion.

So with those grand expectations, we'll have Tip come forward. The first presenter -- well, introduce yourself and your affiliation, if you will, for the committee.

MR. SRIDHAR: Okay. Narasi Sridhar from the Center. Thank you, Ray. I pushed the wrong button here, didn't I?

Okay. In the topics that I'm going to cover in my presentation, I'm going to talk very briefly about historical viewpoint on allow 22, how it came to be, and then going to talk about first insights, and especially focus on localized solution and strip corrosion cracking, what are the predicted methodologies that we are using and DOE's using; hone in on the effect of fabrication and thermal treatment and what our concerns are.

And as I briefly mentioned, the effect of minor acuities in the ground water, then proper -- a little bit about uniform dissolution, because that dictates a lot of the performance in our performance assessment codes.

And then finally, I'll briefly mention the status of the subissue resolution.

The alloy C-22 which is really a family of C-type alloys. The first origin of the alloys was by Edward Haynes and other independently in the UK discovered Ni-Cr alloys in 1898.

Edward Haynes really discovered it to satisfy his wife, who was complaining that all the kitchen knives were routing to corrosion, and so he -- a better alloy to hold the edge.

Later on, alloy C was developed by Union Carbine in the 30's. The problem with alloy C was that it had very high carbide and silicon and ... used as castings, which of course, many of the chemical plants and users didn't like, because they wanted ... products to be used as blades and sheaves for more practical uses.

So -- many people were investigating how to make these alloys into broad shapes, and be ... from Germany, using the newly discovered at the time, argon oxygen carbonization process, double up the low carbon version of alloy C, which is called alloy C-276. I don't know why where that 276 came from. I've never found out after all these years.

C-276 was okay to make materials, and in fact, was the work horse of the chemical process industry for a number of years, and continues to be today. But it had some thermal stability problems, especially ... the material, so alloy C-4 was developed in 1973.

C-4, one of the interesting things about it, is it was also tried out as a candidate alloy by the Germany ... program for the sole repository. And so there is some data available for C-4 in soft text. And in a way -- the reason I'm mentioning this history, is also to say that even though these alloys are relatively new compared to iron and other -- and copper, for example, there is some industrial experience. And we could use that experience, if we can build a framework to ... that experience to determine whether the models that we're using in our performance assessment code are -- provide data confidence in our models, basically.

So C-4, the recent data available, and we have done some analysis back in '95 of the data that the Germans had developed and showed that the models that we're using in terms of ... potential are consistent with what they found in terms of C-4 performance.

Alloy C-22 was developed in '81, because the C-276 and C-4-type alloys were not very useful in highly oxidizing environment, such as nitric acid and so on. They didn't have enough chromium, so C-22 was developed in '81. But surprisingly, C-22 was found to be highly resistant to chloride-containing environments also.

So C-22 was really the place ... C-276 in many applications, and later on, of course, the late '80s, other ... alloys, such as alloy 59 by the German company ... and 622 by the ... were commercialized.

So a lot of these alloys are now being used in ... they test very high in chloride concentration, very highly oxidizing conditions, plus ... gas, which provides acidity.

In chemical process ..., which are all these unpredictable mixtures of environment, ... also has very high concentration of ... in some cases. And, of course, both ... systems which have chloride has an oxidating agent.

So there is quite a bit of history, and one needs to put these various experiences in a map to gain confidence, in order to perform our assessment model.

In terms of what are the issues of, you know, from a performance assessment standpoint for the application of these alloys and containers.

Well, it turns out that because alloy 22 is so highly resistant to localized corrosion, the container life now is dictated by uniform dissolution. And so one needs to understand what the rate of dissolution is, and how to gain a better -- make an ... understanding of this dissolution process, we'll have confidence in the long-term prediction.

The other thing is that effect of fabrication process. What we find is that, especially in the DOE's safety case that I'm going to talk about a little bit earlier, the compressive zone by the thermal treatments to overcome the residue of ... from the ... creates a zone of compressive stresses. The width of this compressive zone becomes an important parameter, to determine the life of a container.

In other words, corrosion has to go through these compressive zone and then stress corrosion cracking takes place, ... data show the width of the compressive zone needs to be ... a little bit better, in terms of the effect of fabrication processes.

And then, of course, the thermal treatments to overcome the problems in fabrication process, changes the microstructure and that may have a ... effect on the corrosion.

And, of course, the importance of near field chemistry is always there, and that's going to be discussed substantially tomorrow, and I'm not going to do

... as much today.

Okay. In terms of the design features. 825 was originally specified in the design, and then later on, 625 was thought about briefly, and then C-22 is currently being used, and it has a ... effect on container life as shown here.

Basically it shows that the percentage of the fraction of the waste package failed for alloy C-22 is a quite bit lower for a given time period, then that of 825 and 625.

Well, why is this the case? If you look at the ... potential as a function of chloride concentration, again, our performance assessment code, the conceptual model is that if the corrosion potential of a given alloy exceeds the repassivation potential of that alloy, then localized corrosion takes place. And once localized corrosion starts, the corrosion penetration is very rapid. So ... starts pretty soon after.

So for a given chloride concentration and a given corrosion potential, if the repassivation potential of a particular material is higher than it is more resistant to localized corrosion and so it lasts longer.

So, for example, the corrosion potential and the repository condition is roughly 0 to minus 200 mV. So if you draw a band from 0 to 200 mV, you can see that ...

extremely low chloride concentrations, roughly the minus 3 order.

625 is a little bit better, roughly about one more, and C-22 is quite a bit better. You almost have to go to saturation of sodium chloride before localized corrosion occurs.

So that's the reason why the performance assessment calculation shows that the percentage of this package failure due to corrosion is much lower for C-22 than for 825.

Now, of course, we have done a lot of studies. Some of you will say ... lab door, to show that the repassivation potential is a good parameter to predict the occurrence of localized corrosion for these types of materials.

Well, how does the effect of fabrication come in? Well, if you look at the repassivation potential, again I'm shown the zone of danger, that is the zone of corrosion potential. In this case, for the higher -- this is for the ... chloride concentration, so the corrosion potential should get to a lower value, come back a lower chloride concentration, because the oxygen solubility is lower at higher chloride concentration ... of it.

So the corrosion concentration is sort that of all orangish-band of minus 200 to minus 300 mV, if I could read the numbers from here.

And what it shows is, if you have non ... material, just a base metal, as shown by the open triangles, the repassivation potential is quite a bit higher than the corrosion potential, so localized corrosion at the 4 ... sodium chloride, at this temperature is not likely for alloy 22.

If you ... it, then you have diffused ..., which is quite a bit higher than the corrosion potential. So ... in this particular case, this is of course, ... of the a thin sample, not a thick container, so there may be differences between the two.

But at least in this case, the ... does not produce tremendous -- it lowers the repassivation potential, but it does not ... into the zone. Of course, we don't have an update to really show the distribution in the repassivation potential. That needs to be generated.

But the most important thing is if you age the material at 870 centigrade for even half an hour, the repassivation potential moves into the danger zone for the alloy.

What this means is that any thermal treatment ... that exposes the alloy to this temperature and this time range, the alloy can be effected adversely in doses of low corrosion.

So this is the concern we have in terms of any post ... fabrication that one would perform on this alloy, and how that could effect the behavior of the alloy.

Well, why is this post ... fabrication a concern? Let's look at stress corrosion cracking as to the other failure mode.

That ... sort of ... streams of investigation. And I sort of tried to put this into kind of a flow chart here.

If you look at the DOE investigation so far, investigation done by Peter Andresen at GE and Lawrence Livermore, have shown that relatively rapid crack growth can occur if you initiate the cracking by some sort of cyclic loading. Dave Stahl is going to present some of that information later on.

The crack growth rates of the order of 10 minus 8 to 10 minus 9 millimeter per second. So if you translate it, then that penetration through ... wall is a decade or so.

So in order to overcome this potential problem identified by a stress growth cracking test, post-weld annealing has been proposed by DOE to create compressive zone, because stress growth cracking ... stresses to open the ... for them to drill.

So if you have compressive stresses, then stress corrosion cracking can be prevented.

So our concern really is that what would be the deleterious effect of this post-weld annealing. What would subject the material to the thermal regime, under which you can enhance localized corrosion behavior.

What will be the range of this discompressive zone? Would it be 2 millimeters, 3, millimeters 5 millimeters, 1 millimeters, we don't know with this material with this limited data. So that is the one stream of activity.

The State of Nevada ... showed some very deleterious effects of minor impurities and ... in the next line. And showed that lead and sulphur and mercury in the solution can cause increased stress corrosion and cracking ... corrosion.

Our concern really is that the data as currently generated by them is not really relevant to ..., but what we need to do is put this in perspective of the ... susceptibility, and I'll talk a little bit about that, what I mean.

Our long work at the center have not shown stress corrosion cracking of C-22, as long as the potential is below the repassivation potential.

Of course, we are not use cyclic stresses, we have used static loading, because that's what we anticipate to be the loading condition in the ...

What we need to do is also do some confirmatory testing to look at ... and look at the minor impurities.

Coming back to the effect of minor impurity. The Catholic University data as it stands now, as I understand it, is that if you add that and in their case, they added lead acetate, ... 1000 ppm concentration, and if the temperature is above 400 degrees centigrade, then ... conditions at pH .5, a tremendously fast stress corrosion cracking can occur in C-22, even under that condition.

They didn't find any cracking at room temperature, or without lead.

They did not establish a critical potential for SCC. That means if you have conditions that the potential of the alloy is below critical potential, would SCC occur or not, is not known, so the true ... of susceptibility of this alloy is not known. And one needs to know this window of susceptibility, in order to find out whether this window falls within the window of anticipated ... field and environmental conditions.

Now, the cracking of lead and alloys, this type of alloy is not new. It's been known since '65, alloy 600. The activation energy is very high, at least very limited data shows that. So test ... centigrade to translate to anticipated ... environments, I don't know what the crack velocity would be. And crack in the alloy 22 has been shown to occur at these kinds of pH's in -- even without lead. So we, at this point, don't know whether lead is a ... agent or just the pH.

So again, the ... of susceptibility for this alloy needs to be established for these kinds of impurities.

So we ... what needs to be done is, the test temperature at this point is much higher than anticipated for wet conditions, 2 ... centigrade that the ... is not going to produce a wet environment.

So the effect of anticipated temperature at the ... stress corrosion cracking needs to be established. The effective anticipated pH of water on the stress corrosion cracking needs to be established. As I mentioned before, stress corrosion cracking has been observed at low pH, even without lead.

The range of lead and other minute impurity concentrations that need to enhance SCC and localized corrosion needs to be established. And the ... of lead in evaporated water is a question. Lead was added as lead acetate, most of it is soluble in the environment, that the test was conducted, but wasn't ... near field conditions. Some preliminary calculation we have done here showed that when you have that much lead, most of it precipitates out as, you know, various lead compounds, and the only soluble species that is predominantly present is lead carbonate, ... carbonate, and that concentration is quite low.

And how does the range of cracking for stability, the potential for cracking correspond to the range of anticipated potential of the ... is another question that needs to be answered.

Okay. Now, going back to the topic of SCC mitigation. Because the stress corrosion cracking tests that are being conducted by DOE, leads to very high crack growth rate.

DOE has proposed that they would remove the ... stresses through local annealing. The laser shot peening is produced for the inner lead and the induction annealing is proposed for the outer lead.

Basically these subjective material to create a high temperature, it will create a compressive zone.

So the temperature profile near the pre-cut zone is something that needs to be determined.

The container life then is determined by the uniform penetration rate of the alloy 22 through this compressive zone. And then once it's penetrated, a rapid failure occurs.

Now, we looked at the uniform corrosion rate, because even in our performance assessment calculations, the uniform dissolution rate of alloy chemicals becomes ..., because of the localized corrosion assistance of the alloy.

And these are the kinds of ranges of uniform corrosion rates that we have observed. We measured the uniform corrosion rate by monitoring the current density, the anodic current density, because you can monitor current density much more accurately into the grade of a solution, than measure weight loss, and calculate the end ... corrosion rate.

And you can see that rates of uniform corrosion rate can lead to very high lifetime. If a concentrate of this solution is assumed. And we have shown the rates that are assumed at the TPA Code.

The assumed rates of uniform dissolution for DOE is roughly a ... 92 lower.

We have measured the uniform dissolution rate as a function of ... potential. And what you can see is that the -- on the right-hand side, the dissolution rate increases, but it accurately ... with these very high potentials are not likely, but possibly, because you don't have transpassive conditions.

The corrosion potential is more likely to be in the minus 200, because ... minimal range at which the passive dissolution rate is relatively constant, with respect to potential, because you're getting a leakage through an ... and the corrosion rate is essentially independent of a chloride concentration.

So the growth and rate is not a great function of the ... field chemistry, as long as you maintain human form dissolution rate ... localized corrosion.

But the uniform corrosion rate depends on the microstructural conditions; that is, the thermal treatment that the material is subjected to.

What we have shown here, is that both in the as-received condition and the welded condition, that is when you weld it using the appropriate procedures for the alloy, the uniform dissolution rate is pretty low, and is not a function of fabrication.

But if you thermally treat it, in this case, we have exposed it for four hours at 800 degrees centigrade, which is just a mimic of possible thermal explosion and doing .... treatment. You can get extremely high corrosion rate ... corrosion constant of intergranular.

So the question really is, who would get the material into this condition, to have very high corrosion rates.

The next thing we wanted to do was get a better understanding of the uniform dissolution behavior of the alloy. Because most of the lab estimates are pretty short-term, and we want to find out what would be the processes that ... uniform dissolution of this alloy.

One of the proposed models has been ... model called the ... defect model.

Basically, the model assumes that you have an alloy on the left-hand side, and then you have a passive ... that's essentially chromium oxide ... in this case, we assume it's a crystalline filament of chromium oxide. And then the right-hand side is the ... solution.

And the dissolution occurs by the movement of point defects within the chromium oxide. You have similar types of point defects. You have, of course, the oxygen in position that move from the left to right, and you have the vacancies where there is not a chromium presence, so these are negatively charged species that move from right to left, and especially, if there is chloride in that environment, they will move faster, because of their having force of the charges, and then you have other ... defects of ... of nickel, and chromium and ... that move from left to right.

So the net dissolution rate, that is the capital I in the bottom is the effect of these various movements of these charges within these outside ...

That's what the model proposes.

Unfortunately, the problem with this model is that you don't have a very good idea of what all are the ... are. They are not easily determined independently.

So what we have done, I should say me, I should say a ... in our group who did more on the calculation is ... going back to the -- we know that capital I through experimental measurements and by estimating various K values, we can play with what will be the proportion of contributions from the different processes to the net I.

And one of the main concerns for us is really that the net movement of these point defects creates vacancies in the metal. Here the picture is the worst of the previous line. The oxide film is on the left, and the alloy is on the right. And what happens is, due to the net movement of these point defects, you inject vacancies into the metal.

So the first thing is really that, for the short time period, these don't matter because the injection of the -- the rate of injection of vacancies is very small, so we won't even see it.

But over 10,000 years, these may be quite substantial. So would it have a negative effect on the performance of the material is a question we're trying to answer.

Again, this falls into the category of have you thought of processes that, you know, basically people haven't thought about that ... that have a ... effect.

So this is one of the concerns that we have is, what we have in vacancies injected into the alloy to increase the dissolution rate of the material.

And what the calculations show and here I've -- I don't want to go into the detail, but we have sort of a number of different cases we have evaluated, based on different K values that we have assumed. And you can see that failure of ... anywhere from 30,000 years to an extremely high number.

And what needs to happen is, this model needs verification. Basically, what we are trying to do here is, we pulled the one level further in terms of understanding the dissolution behavior, and this is one of the models that look promising, in terms of explaining the uniform dissolution behavior of this type of alloy. But it raises some questions on the generation of point defects within the alloy that need some ... experimental verification.

Of course, experimental verification of this model is not easy, because the rate of generation of these point defects, and the rate of injection are extremely small. And so very sensitive measurements need to be made. And that's something that we have grappling with on how we're going to do that.

Okay. Finally, issue resolution, we had a ... exchange as mentioned before on container life and source term, and all the subissues are, at this point, closed pending. The back-up slides, I've provided some details on the agreements.

The one thing I want to note is that on slide 22, that ... I mention that it's a document that was to be supplied in ... yeah, the document that was going to be supplied in January 2001 is really going to be supplied by a later time frame. That's the .... chemistry, especially effect of minor constituents.

That's the end of my presentation. Are there any questions?

MR. WYMER: John, do you have any?

MR. GARRICK: Well, it seems that everything hinges on the ability to control metallurgical conditions, and how are we going to evaluate that?

MR. SRIDHAR: At this point, DOE's making some mock-ups of different scale containers with ... and different post ... treatments. And our hope is that we will follow what they're doing, and we would like to do some conformity studies. Ideally, we would like to take some materials from their desk and perform a ... studies.

And the two things that we would like to examine are one is the microstructure of the material is stationed, how the microstructure changes around the weld and the ... treated barriers. And secondly, what effect does this have on the corrosion performance. Those are the two things we would like to evaluate. Of course, we would like to follow DOE's evaluations in those areas. And we have scheduled a series of meetings in the coming year, to examine. These are some of the items that we have as part of our agreement, this information that DOE will be generating.

MR. GARRICK: Are there any other materials under consideration that you're aware of?

MR. SRIDHAR: No. I think C-22 is the --

MR. GARRICK: Is the chosen?

MR. SRIDHAR: Is the chosen candidate, and DOE will --

MR. STAHL: I'll address it.

MR. SRIDHAR: Okay.

MR. HORNBERGER: First of all, just a quick question, following up on what you just said.

How do you propose to look at the microstructure surrounding welds?

MR. SRIDHAR: Either just by optical metalography or --

MR. HORNBERGER: Oh, okay.

MR. SRIDHAR: You know, depending on the need, we can also do some ... electronic ... which we have done in the past for ... characterizing the -- essentially when you have ... you get depletion of chromium next to the ... boundaries, and that's something we could characterize, DOE would like to.

MR. HORNBERGER: So I -- the way I heard correctly from what you said, that the center does have plans to look further at the effects of both stress corrosion and cracking, and the influence of trace materials?

MR. SRIDHAR: Right. We would like to look at that. But we would like to look at that in light of possible near field conditions.

MR. HORNBERGER: Right. And -- but these are planned experiments and not ongoing?

MR. SRIDHAR: They are -- will be started pretty soon. That's -- they are planned for this fiscal year, but we haven't started experiments yet.

MR. HORNBERGER: Okay. And how long do you anticipate these will run? For several years?

MR. SRIDHAR: I hope so. But it depends on the particular test results, you know, the cracking, of course, is very fast, the test will be over soon, but I think that leaves for ... we haven't planned for the future, so I can make a commitment for ...

MR. HORNBERGER: And can you -- you plan that these results would feed back into your mechanistic model?

MR. SRIDHAR: We would -- we are hoping to do these tests as a function of potential.

MR. HORNBERGER: Uh-huh.

MR. SRIDHAR: And what we want to say is, we want our data ... back into our picture conceptual model of repassivation potential being that ... So if -- it would treat back into the performance assessment model into that parameter. That is our hope at this point.

The experiments dictate otherwise, then we have to reconsider our conceptual model.

MR. HORNBERGER: Yes. And do you have an anticipation as to what you might see under the conditions more near repository conditions?

MR. SRIDHAR: My feeling is that I don't think they would see the ... effect of ... in stress corrosion cracking on ..., I may be wrong. As far as the effect of sulphur, we had looked at in the case of alloy 825, we had looked at sulphur compounds, and they did have a deleterious effect on ... concentrations.

So that's ... area of interest that it's not stressful from cracking, but that .... localized corrosion. So we would look at ... sulphur. And, in fact, that may tie with the effect of microbial organisms, because one of the concerns we have is whether microbial -- microbiological organisms can cause localized corrosion of this alloy. And one mechanism may be local generation or these sulphur or subflax fusions.

And so we can again tie that effect through our conceptual model as well in repassivation eventually.

MR. HORNBERGER: Has there been work by -- I don't think ... the Center on MIC, but have other people done work on MIC for --

MR. SRIDHAR: We have actually done quite a bit of work on MIC at the Center. We put it in obeyance because that based on our earlier studies, especially for alloy 22, it was not as great a concern as other. So we had to prioritize our work. And so we had put that as a lower priority, and we had ... to follow what DOE's doing. And Lawrence Livermore is doing quite a bit of microbial work.

What they are finding is, that the microbial qualities increase a general corrosion rate, and our concern is really is that we investigate the effect on microbial organisms of localized corrosion.

MR. HORNBERGER: Thank you.

MR. LEVENSON: I just have one question. You indicated the aging phenomena at 840 degrees. Is there any indication that that occurs at lower temperature, at much lower rates?

MR. SRIDHAR: It does. There is a C-shaped curve for these things, as many other ... transformation. And that ... which is essentially a metallic phase called new phase, precipitates, and we chose 870, because 870 is the nose of that transformation curve, so it occurs in a very short time. So in a way, it's sort of accelerating the process.

But it cannot ... centigrade over a hundred hours and at lower temperature for a much longer time.

MR. LEVENSON: Well, how low a temperature? Would it be occurring at repository temperatures?

MR. SRIDHAR: That new phase is not likely to ... temperature. ... are extremely slow. What is likely to occur at repository temperature may be longer in ... provided you have ... the material. If you have a completely new material that even long range ... is too slow, ... repository temperatures. So it has a combination of circumstances for ...

MR. LEVENSON: It seems pretty slow over a lot of years.

MR. SRIDHAR: Yeah.

MR. LEVENSON: 10,000 years.

MR. SRIDHAR: The long range study has been done both by Lawrence Livermore and by ..., looking at these alloys in that ... condition, to show that it's not likely to occur.

But in terms of the localized corrosion phenomena, what is of concern is the higher temperature phase.

MR. WYMER: I have a couple of questions. They go mainly to the nature of the dissolving solution that will be used in the test and the first ... evidence such as it is for trace elements on the ... of the solution, the corrosion. Maybe it's dissolution at that range ....

First, are you planning to do any additional extensive mountain water characterization, what is likely to be really in there, as opposed to J-13, which may or may not be typical of what's in there?

MR. SRIDHAR: I think that's something ... are more likely to ... but we are ... to look at that.

MR. BRENT: This is Brent from the Washington, D.C. office, NRC staff. In effect, if you get a chance to review the thermal test, I believe the lower ... unit is being used in the most recent thermal test. And the Center has incorporated that rock with water and they are going to be running the chemistry on it, including the trace elements.

MR. WYMER: Okay, great. And the .... a suggestion at least ... very short concentrations can have a very large ... Now, are you getting any consideration to the -- this is a topic you all discussed at the break, to artificially introduce materials into the repository and one of the examples that's mentioned, is the possible use of ... labs which might break or maybe the insulation on electrical wires that might provide the source of organic treatment of ... those materials that you wouldn't really expect to be there, but they will be there. Are these kinds of things being ...?

MR. SRIDHAR: We haven't talked about the sources of these ... Obviously, we would like to include the effect of lead, sulphur and mercury in our tests to see what effect ... concentrations. But we haven't really thought about what sources and how they would ... And that's something we are working with and ... KDI to really determine what the ... issue would be, you know, what are we really having ... solution with these species.

Now, as far as organics, we haven't really looked at it. My feeling would be that a lot of the organics are also corrosion inhibitors. So --

MR. WYMER: You don't ....

MR. SRIDHAR: Yeah.

MR. WYMER: ... mechanistic studies, how deep are you going to go in that direction? How much are you going to try to understand the effect of corrosion? You have one model that you're working on, how far are you going to go?

MR. SRIDHAR: Well, I don't know, to be honest at this point. I think what we are concentrating on, and over the last few months, and this year, ... on issue resolution and prioritizing where we make the ... you know, especially this minor element effects and so on.

In terms of going further with the modeling, my feeling is that we need to do some critical experiments to verify some basic assumptions that the model is making, in terms of the ... defect movement.

And we have talked about what experiments we will do, but we haven't really gone into depth in terms of what type of resolution we need, in terms of measuring capabilities, and what really will be the type of experiment we will do to create these conditions. That some things we have talked about, but we haven't planned it.

MR. WYMER: Okay. Any other questions? Jim or Rod, do you have any --

MR. EWING: Maybe just a follow-up on your question.

In the experiments you've done or that you envision for developing the model, do you look or do you use cross-sectional transmission electron microscopy to look at this thin layer? It would be maybe ten microns thick if I'm calculating correctly, and so it should show up very prominent.

MR. SRIDHAR: That's one thing we have thought about. One of the problems with that will be the act of making the sample would disturb it, because you have to do at a ... to get the thin layer for transmission of electron microscopy, so the act of preparing the sample may actually disturb the phenomena that we're observing.

MR. EWING: Yeah.

MR. SRIDHAR: The other possibility is to look at ... changes. For example, the ... is extremely sensitive to foreign defects. So if you're injecting vacancies to the metal, and if we can measure ... very sensitively, for example, a very high frequency of ... measurements, you can possibly detect additional point defects.

But concentration upon defects injected is very small with short time periods, so it makes a big difference in long time periods. So we have talked about different ways of measuring the sensitivity changes, and that's something we haven't come to a, you know, decision on.

MR. WYMER: Andy?

MR. CAMPBELL: Mr. Sridhar, have you guys done a series of experiments to try and bound the kinds of chemistries that will go on ... or water and salts on the surface of the waste package, as opposed to a bulk water chemistry cooperating with, you know, some one of the layers of top rock, is you know, and that may be your incoming water at some point, but it's going to cooperate with the surface of the waste package with a variety of things that could be there. It may have interacted with some iron, you know, as it came to the drift wall and so on. Have you looked at a range trying to bound that environment?

MR. SRIDHAR: We have done only limited work in that area. We are following, more or less what Lawrence Livermore has done, ... what we have done. We have done some work of the ... steel with the outer container and we have looked at the effect of alternate wetting and drying on the ... chemistry. But for the alloy 22, we have not done.

The environments really using ..., which is essentially a concentrated ..., but much more corrosive than you just concentrate the dirty water, because you're also concentrating inhibited species like nitrates. So we feel that we are already on the conservative side on that.

I don't know that if that answered your question, but that's very ...

MR. CAMPBELL: But, you at least, or somebody's looking at all these various interactions --

MR. SRIDHAR: Yeah.

MR. CAMPBELL: -- to try and nail down what kind of speciation and water chemistry might occur at the surface of the waste package.

MR. SRIDHAR: Right.

MR. CAMPBELL: Okay.

MR. SRIDHAR: And the only other thing of that area we're focusing on, is the impact ... chemistry, and you will see tomorrow the labs and experiments we are doing.

What happens to the chemistry of water, once it penetrates through the C-point ... and interacts with the ... That's an area where we are focusing on, because we feel that very little is being done in that area, and modeling of that environment ... very difficult, because of the number of components involved and so on.

MR. CAMPBELL: Do you guys have a handle on the kinds of stresses that will be left on the surface of a waste package, I won't say if, when chunks of rock fall out of the ceiling of the drift? I mean, over time that -- the drifts are going to collapse, and they're going to be dropping rocks presumably on the drift shield, but those may also get through and get on the waste package. Do you have a feel for what those stresses are?

MR. SRIDHAR: Right. Those are being dealt with. I think ... and Simon ... are doing some of that work as part of the ... TTI. But we feel in the recent performance assessment calculation, the stresses from the risk ... stresses are assumed to be close to the yield strength and that's what we are using for the failure, the mechanical failure of the waste package.

MR. WYMER: Anybody else? Thank you very much. Now, we're going to hear from David Stahl of -- representing the Department of Energy; waste package materials, concerns and testing program.

MR. STAHL: ...

MR. WYMER: ... concerns first.

MR. STAHL: Gentlemen, thank you. I'm David Stahl with the Yucca Mountain Project. Currently, as indicated here, I'm a materials advisor to the program. I used to be the head of the department that was involved with materials testing and evaluation, and as most of you know, I've retired from that position, teaching at ULNV, and doing some part-time consulting work.

... is now is now the lead for that effort, he's in the back, and the gentleman responsible for most of the corrosion testing is Dr. Gerald Gordon, also in the back of the room.

As far as the ... is concerned, what you'll see is that I have a fairly reduced sized presentation and a lot of back-up material. And initially this was done because the message that we got was that we only have about an hour in total time, and so we said, okay, let's move all of the, perhaps interesting to corrosion people, information to the back-up section.

And now we have additional time, so what I'd like to do is, as we move through, pull in some of the back-up slides as they're appropriate to the presentation. So with your indulgence, we'll go ahead and do that.

As you can see from the outline, I'm going to touch on materials selection. In this regard, Dr. Sridha has given a very excellent presentation that forms a very good basis for what I'm going to say.

Talk briefly about the testing and prioritization effort, get into waste package environmental conditions, general corrosion, localized corrosion as you can see, long-term passive film stability, stress corrosion cracking.

For each of these subjects, I'll talk about basically where we are right now, and talk about some of the concerns and then for each, indicate the path forward.

By a way of background and materials selection, we had a set of criteria that we developed early on, and basically they were responsive to 10 CFR Part 60, and the other criteria that we had developed as part of the project, including the engineered barrier system design requirements document.

The current criteria flow from proposed 10 CFR Part 63 and we now have a project design description document, and system design description documents.

Now, we had the first survey of materials conducted a week back in 1983 by Lawrence Livermore. And as most of you remember, we had a thin wall design, which was a stainless steel Type 304-L. And in that survey, we had four criteria; corrosion rate, mechanical properties, weldability and cost.

And we used the similar approach for the current design, except that we've enhanced and expanded a number of criteria. We've included, as indicated there, compatibility and predictability, fabricability, thermal and neutronic performance, and industrial usage and experience.

Lawrence Livermore conducted a lot of literature in his, degradation mode surveys, and limited prototypic condition tests. And the objective there was to narrow the materials of interest for the waste package barrier.

Testing, as indicated in the second bullet was concentrated for materials ultimately selected; however, we have a wider range of materials that underwent both long-term and short-term testing over a wide range of environmental conditions. And you can see the conditions there are pH from 2.7 to 13. The pH 2.7 was based on the fact that we thought we might have some organic or microbiological reactions that might pull us down to this range, also ... crevice chemistries, and the pH 13 was driven by a potential for interactions with concrete material, which was the original design of the liner for the drifts.

Temperatures as you can see anywhere from 25 to 120 degrees centigrade. As indicated, a last bullet, and alloy 22 was selected for the waste package outer barrier and titanium grade 7 was selected for the drip shield.

Now, as Sridhar has said, the good news about alloy 22 is that it has a very low corrosion rate. The bad news for alloy 22 is, it has a very low corrosion rate, and so you have some uncertainty problems in being able to measure that rate.

If we can go to 42 of the back-up, basically it indicates some of the other materials that we have in the test program. These included a host of corrosion allowance materials, mainly, as you can see carbon and alloy steels, and we had some copper and copper alloys, including copper aluminum and nickel copper alloys.

We have a variety of different corrosion resistant materials, as you see there; stainless steels, nucleoid, geneloids, such as GE 3 and GE 30 and 825 and nickel-based alloys 625, C-4, 22 and 59, that's mentioned by Dr. Sridhar, and the titanium alloys of 27, 12 and 16.

And as indicated in the last bullet there, we also investigated some surround-coated materials, and we do have some zuchonium alloys that are also being evaluated as part of a cooperative program with the Navy.

MR. GARRICK: What eliminated the titanium alloys?

MR. STAHL: They weren't eliminated. Actually, they had, as far as the selection is concerned, that was based on cost. We felt that the titanium alloys were very similar in writing to the C-22 or alloy 22, most generically, and so the alloy 22 was chosen as the preferred method.

At the time, there was also some concern about the weldability of the titanium and that still is a concern, so for those reasons, the alloy 22 was the preferred corrosion resistant material.

MR. GARRICK: And those issues are not as important when using it as a drift shield?

MR. STAHL: Correct. Going back to number five. You're there.

MR. WYMER: Okay.

MR. STAHL: I thought I covered that.

So basically, we selected alloy 22 as Dr. Sridhar noted, we started out with 625, about four or five years ago, and found it had some problems with localized corrosion resistance, pitting particularly. And so we moved to 625, found that it too, had some problems, and three years ago, moved to alloy 22. And as a result, we don't have a lot of data that the program has generated, but there is a significant amount of data that's out in the literature that we have utilized in our analysis.

As indicated here, our alloy 22 is resistant to general crevice, pitting and corrosion. It is resistant to stress corrosion cracking under environmental conditions that we expect at Yucca Mountain, and I'll show you some of the test data.

It has an excellent face stability under low temperature aging. We'll talk about that. And it's easily weldable, fabricable, inspectable, using existing processes.

And I don't know if I mentioned in here, but we do have several mock-ups that we've made of alloy 22, and we're continuing to make some mock-ups that are close to full scale, and we will section for testing some of those issues that Dr. Sridhar mentioned.

This is a summary of the chemical compositions of the alloys. As you can see, alloy 22 is an nickel-based material, roughly 22 percent chromium, 13 percent molybdenum, 3 percent iron, ... of actually you can't get rid of all of the cobalt, so there is some cobalt in there; tungsten and 0.35 vanadium.

Dennis, when he was at the DOE noted that vanadium was not in the legend box, I apologize for that. The V in the first entry is vanadium.

You can see the differences between some of the pre-cursor alloys, the C-4, for example, doesn't have the tungsten, but the tungsten and moly are roughly the same composition. It has a little more nickel and a little less chrom.

And you can see in the compositions of the 825 and the 625. The 825, as you can see is really nickel rich. It's not nickel-based. It has 30 some-odd percent of iron. I've also included in the chart of compositions of alloy 600 and alloy 690. These were mentioned by Dr. ...'s potential ... for alloy 22. I might say it's not a very good analog, but that's the best that we have, as far as some long term data. We do have some others, and I'll put it up in a minute.

As you can see, the 600 and 690 alloys do not have any molybdenum, and no molybdenum does help in localized corrosion resistance.

The next chart indicates where we are in prioritizing the effort, and basically our ongoing and planned work is focused on reducing uncertainties and corrosion performance with an emphasis on stress corrosion cracking, and ... stability.

Now, we have a lot of long-term and short-term tests that are under way at Lawrence Livermore lab. We have other tests going on at the Alliance Research Center, Atomic Energy of Canada, University of Virginia, General Electric to address these key uncertainties.

We also have studies underway to look at stress mitigation, and these are underway at Lawrence Livermore, Framatome, Structural Integrity, Lambda Research and Ajax.

What I want to do is just to divert from the program for just a minute, is to show these charts, which are not in your packet, but I understood that the committee has not had a chance to go to Lawrence Livermore Lab. And I think the people at the NRC have seen these first hand. This is a chart of the long-term corrosion test facility. There are 24 tanks. They're about one meter square, and about a meter and a half in height. And they have a variety of different chemical environments, and I won't show the chart, but on page 44 of your back-up, it does have the chemical compositions of those different waters that we've tested.

Basically, sitting water is down to 2.7, with concentrations up to 1,000 XJ 13. And on the basic side up to about pH10, and we've also established some tests with concrete modified water, and we will be doing some additional tests with some of the more aggressive waters that we'll talk about.

This is a rack that was taken from the test. There are six rack positions in each of those tanks, and you can see that we have about a hundred specimens in this rack. All together in the facility, we have about 15,000 specimens under test.

You can see the gentleman there is pointing to some crevice corrosion specimens. They're also over here. These are weight loss coupons over here, and we have some uban (phon.) specimens, both below the water line and in the vapor face. So a variety of different specimens.

You can see there's a closer view in the next picture. This shows some carbon steel specimens, before and after tests, confirms the fact that carbons rust very nicely, and in fact, we had very good comparison between the corrosion rate that we observed, and the corrosion rate that we predicted for carbon steel.

The next chart shows a picture of alloy 22. That's one of these crevice corrosion specimens, and you can see in the creviced area, just a hole of staining. This was the --

UNIDENTIFIED: Was this a two year test?

MR. STAHL: This was a one year test at 90 degrees C in acid water.

This next chart was taken by the nickel developed associates, and this is what analog material has done to streethard (phon.) and noted, this tends to be a pestoloid C and this was taken after 56 years of exposure at Curry Beach, which is a salt water atmosphere. And as you can see, after 56 years, we still have a nice mirror finish on this particular material. So we believe we'll have similar, if not better results for alloy 22.

Okay. Let's go on to talk about some of the waste package environmental conditions. As I mentioned, a large fraction of the corrosion test that we conducted to date have been with concentrated solutions of J-13. Basically we've got that concentration levels. This was a result of a workshop that we had at Livermore, and these were from geochemical experts, and they suggested using 10X, have a thousand XJ-13, as a waters for the testing.

And as I indicated, the next blow-up we do have some concrete modified water, which was added later on.

Now, we will be starting up some additional tests shortly in those long-term corrosion tests facilities, with some new founding concentrated waters, as our new tanks are being installed. So we will be adding, it's about a half a dozen different tanks for that particular facility.

And by the way, I do suggest that the committee come to visit Livermore, and look at this facility first hand. We also have other facilities that are looking at microbial corrosion. I'll talk briefly about that in passing, and we have some relative humidity chambers, where we have some static and drip testing that's also under way.

Now, as you know, the drift shield provides protection for the waste package from direct water contact, and evaporative concentrations for times greater than the regulatory period as indicated by others previously.

But you still have the potential for waste package surfaces, having some dust and other deposits on them. And it's possible that they could develop near saturated deliquescent and salts, either directly from that water, or from the dust and any salt concentrations that might be part of that.

The critical relative humidity, it appears to be about 50 percent. When you get up to about a hundred percent, as indicated in the final bullet, the surface solutions tends to be more dilute.

Now, when we take the J-13 water, we've done both some PQ36 and some direct concentration testing and developed -- excuse me, the chemistry of the waters after concentration.

(Interruption.)

MR. STAHL: Shall I continue, Mr. Chairman?

MR. GARRICK: Yes.

MR. STAHL: As indicated in ... bullet, we have the potential for a bicarbonate base, and that basically accounts for the first orders of T-13, and the pH there can approach a pH at 13.

You also have pore waters which are non-bicarbonate, and the pH there can become slightly acidic, depending on the calcium and magnesium content.

And if you look at chart 43 in the back-up, it does show you the compositions of the J-13 and the pore water that we start with.

And if you look at chart 46, in the back-up, what I've shown here is some of the work at Lawrence Livermore, where they followed the concentration of the remaining water, as a function of time. And what we've selected as indicated here, at 90 percent water removed, that's the BSW or the basic saturated water, which has a pH of about 13, and is indicated there of one point of about 112.

MR. HORNBERGER: Where does the pore water come from?

MR. STAHL: Pore water comes from the water that resides inside the unsaturated rock.

MR. GARRICK: How do you get it out?

MR. STAHL: Well, there's a great effort to try to collect that water. There's a variety of different techniques, such as centrifugal testing, to try to pull that water out without modifying it too much.

And so there's a science all by itself in trying to extract pore water chemistry. I don't know if they're going to talk about that in tomorrow's session or not.

MR. HORNBERGER: On your slide 43, you show a chemical composition.

MR. STAHL: Yes.

MR. HORNBERGER: So that water was taken out with cebtrifuge?

MR. STAHL: I'm not sure what the process was for that particular water. Gary, do you know the answer to that one?

GARY: I'm not sure.

MR. STAHL: Okay.

MR. LESLIE: This is Bret Leslie from the NRC. These samples were taken from alcove 5 from the middle ... and they struggled mildly to get water out, and there's three measurements. This is one of three. I'm not sure if it was done using the cebtrifuge method, or whether it was by actual compression.

MR. HORNBERGER: Thanks, Bret.

MR. STAHL: Okay. Let's go back to -- And although the State of Nevada studies are very under aggressive and unexpected conditions showed some attack on alloy 22, literature data at 150 degrees C and 200 degrees C with 25 percent sodium chloride and 135 ppm of lead chloride showed no cracking. This is the results by Juri Kolts as indicated there and reported in NACE, Corrosion in 1986.

Later on, I will show you some slow strain rate tests that we've just completed last week on lead, which showed that there was no impact of one percent lead chloride in water. So we'll get back to that.

As far as the bounding water compositions. Here, we show them on slide 12. As I've said, these are waters that could concentrate on the warm metal surface by repeated wet/dry cycles from water drips.

And you can see the basic saturated water, high in chloride, nitrate, sodium and potassium, of course, and the pH is around 13. The simulated saturated water, which is the concentrated pore water has, as you can see, high potassium, and nitrate. And about the same chloride level as the basic saturated water and the pH there is slightly acidic at pH 6.

So we have a range of potential water chemistries that we're already testing, but certainly the concern is that we don't know what the specific water that a waste package could experience, and that could lead to only conservative assumptions.

We have some unlikely scenarios that may cause enhanced corrosion, such as high concentrations of biliterious trace metals, trifilaments, for example, lead or brines from pore water. That is a principle concern. These are the principle concerns as far as the environment is concerned.

We have identified a path forward, and many of these items were already covered or noted by Dr. Sridhar, but I'll walk through them very quickly.

As far as the environment is concerned, we certainly are going to continue to monitor and evaluate the waters that are collected from the drip scale heater test. We're going to determine these concentrations and chemical form of the minor constituents.

A lot of the tests that we've done, has been with synthetic J-13 water, so we're going to go back and repeat some of those with real J-13, and determine or confirm, I should say, the heavy metal concentrations that we have in those waters.

I'm also going to indicate -- if you turn, rather, as I indicate in the last bullet, the minor species solubility and the precipitate species in the minerals formed using some computer modeling.

So that's our situation as far as the environment is concerned. I want to move on to general corrosion.

As I indicated before, and mentioned by Dr. Sridhar, corrosion rates for alloy 22 are very low. The tests were done, as indicated, 10X and -- actually, at the 3,000X J-13 over those pH and temperature ranges. And as he indicated earlier, we have an up about rate of about .07 microns per year. We have a mean rate of about .01 microns per year.

And based on these observed rates, as you can see, waste package failures do not occur before 10,000 years. And this is consistent with what Dr. Sridhar had shown in his chart.

Now, we have a whole host of short-term

electro-chemical measurements, to determine basically the same rate, and they're consistent. We have as well done, the high volume point and the chloride saturated water, and the basic saturated water, and basically, as I said, we have the same passive corrosion rates.

Now, we do have some uncertainties accounted for in the model, and as a result of microbial corrosion and thermal aging effects.

The microbial corrosion, I can refer you to chart 48. Here we have some -- I don't know if you can see that very well in the chart, on the display, but you can see it in your hand-out. There's two sets of symbols. We have symbols for 625, alloy 22 and stainless steel.

The open symbols, excuse me, off of the 8 biotic case, and that is no bugs, and the closed symbols are for the biotic case, and that is presence of a synergistic colony of microbes that are representative of those that we collected at Yucca Mountain. And you can see in a range of two to four times the corrosion rates for these materials.

And so for the enhancement factor, we used a factor of two, and we used a sampling using a triangular distribution from basically zero to four on the rates.

And you can see, as indicated here, that we did have some chromium ions that were detected in solution, when you have the microbes present, as opposed to no chromium detected, particularly for the alloy 22 specimens.

The thermal aging, I don't have a back-up slide for that, but basically it was a result of projections that were made by Dr. Tammy Summers at Lawrence Livermore Lab. She's studying the generation of secondary phases and aged materials. And she's utilizing the data that's available in the literature. I'll just mention, the Haynes long-term data. We have a whole host of samples that we have under test at a variety of different temperatures, and we will be conducting some microanalytical investigations of those samples, to determine the precipitation of secondary phases, to try to get a better handle of kinetic formation.

As Dr. Sridhar has indicated earlier, we do have this nose of a curve for the kinetics of those transformations, and we believe that the temperatures of concern in the repository, that we will not have any impact on secondary phases. But to be conservative, we have a factor of two and a half on the corrosion rate.

As I mentioned, we just started some drip testing on heated surfaces. We did some tests at the Atlas facility, with and without backfill. And we've exposed some samples at Lawrence Livermore Lab, to periodic dripping water, with complete evaporation. And I have some additional slides in the back-up.

Page 49, for example, this gives you some of the background for the Atlas tests. These are quarter-scale tests. We did evaporate ... water on the drip shield. Various materials were tested, as indicated there, the Titanium grade 7, alloy 22 and carbon steel.

This was actual J-13 water that was used, and in test number four, which I'll show you in the next chart, included the backfill, which was an Overton sand.

In the next chart, you can see the two tests, test three and test four. Over here, this is the sand and this is the drip shield, and this is the simulated waste package.

The next chart shows some coupons, these were Titanium and alloy 22 that were in the drip shield, basically setting on top of the drip shield, and you can see that we have significant staining from the blue dye that was used in the water, but no interactions.

We did have some surface oxidation on the right-hand side with the Titanium.

This is without the backfill. With the backfill in test number four, you can see basically the surface is fairly clean, but we did have some silica deposits, and again, you can see it better hopefully on the pictures that you have in your hand-out.

MR. WYMER: Now, that basically diverted the water?

MR. STAHL: For the most case, it diverted the water down to the sides, that's correct.

Now, on the test that we have done at the Livermore Lab, I guess we can go to 53 in the back-up, has the same information. Basically, we used a 100x bicarbonate water, specimen temperature of 93 Centigrade, system relative humidity about 60 percent, test duration of about a month.

And looking at alternate wetting and drying of those samples, as I'll show in the pictures, we have these little bath-type configurations with the specimen on the bottom of the surfaces, are heated from below, and we've deposited both the bicarbonate and the chloride sulfate base water.

You can see the set up in the next chart. This is within that relative humidity chamber that I indicated previously. And the next chart gives you a blow-up of the sample I think that's on the left-hand side. You can see, this happens to be a welded sample of alloy 22 at 93 degrees C.

Basically, no interactions at this stage, but you can see that we have significant salt build-up. I guess I could've shown this other one first. This is a clean test prior to test. You can see the thermal couple over here, and there's also some thermal couples underneath, and you can see the fact that there is a little bath there, so we can collect the deposits. And I guess this picture on the right just shows you the overall view of the specimen and the heater.

MR. WYMER: That's a plastic set-up?

MR. STAHL: Yes. Let's go back to 18.

So these are the concerns of general corrosion. Basically that we need to do some testing with concentrated solutions that include a variety of different Yucca Mountain waters, as indicated in some of the discussion that we had Dr. Sridhar's presentation.

We note that the variability and uncertainty are large, due to the very small values of weight loss.

We need an independent method to verify these low rates, and certainly as indicated, by Dr. Sridhar and others, we certainly have concern about extrapolating those long -- those rates to very long times.

Basically, we're going to use these new bounding test environments in the long-term corrosion test facility. I've already mentioned the basic saturated water, the simulated saturated water.

We're going to continue tests into the

performance confirmation period, with periodic evaluations, and we'll perform some insitu monitoring and coupon testing.

We'll study analog materials and data for similar alloys. As we mentioned alloy C-4 and some of the other C alloys that have been around for 50 or 60 years, so there is some experience data that we might be able to take advantage of, that would give us confidence in our model predictions.

We're going to install some thinner and larger surface area coupons, hopefully to reduce measurement error. We are going to test different heats of material and we're going to, among other things, install high density -- excuse me, high sensitivity probes in some vessels to permit on-line measurements.

There are techniques that we're going to utilize as well. For example, the atomic force microscope. We have initiated some of those measurements already, and it's given us some data that's consistent with the long term results that we've generated to date.

There are other techniques that we'll utilize. Dr. Sridhar mentioned electrochemical impedance is a very promising technique, as well as linear polarization, and we plan to utilize those to corroborate these very small rates that we measured in the long term corrosion tests facility.

Okay. I want to move on to localized corrosion. As indicated, again by Dr. Sridhar and others, localized corrosion is not expected, based on extensive literature in the -- excuse me -- data in the literature, and that collected by the Yucca Mountain Project.

We've done a lot of cyclic polarization measurements, as has the Center for a variety of different environments, as indicated here. And as I indicated previously, the passive corrosion rates are similar in all relevant environments.

I should mention in the long term corrosion test facility, a good fraction, I think it's 40 percent of the samples are welded. And we haven't seen any preferential weld intact, but we will continue to study that.

We have, as indicated in the last bullet, a significant margin between the corrosion potential and the passive film breakdown potential. So again, that's a good reason why you don't see localized corrosion for those materials.

And for those of you that are interested, I have in the back-up, electrochemical potential tests. These are just a couple of tests that we've performed -- excuse me. These are just a couple of figures of the dozens of tests that were performed, would show that for alloy 22 and the simulated saturated water and for the saturated acid waters that we don't see in the tech on alloy 22.

And we've done some testing on alloy -- excuse me, of stainless steel, and you get significant attack for stainless steel under those conditions.

In 22, we show the little lolly-pop test, a different technique for crevice corrosion. And you can see on the left-hand side that here we have tests that ran to 550 milibolts, a 100 degrees C in basic saturated water. Even under those conditions, you do not see any crevice attack in alloy 22.

In the middle chart, push that all the way up to 800 millivolts and 110 C with basic saturated water, again, no crevice attack, but there is some staining.

On the right-hand side, where we have an unbufferred solution, 100 degrees 4M sodium chloride, you can see that we do have a 350 millivolts after two hours, you do see crevice attack.

These are some of the samples that were done. This is a slow strain rate test. You can see the sample geometry, and basically these are the ones that did not show any attack. Let me see if I have -- yes, I do.

Now, if you look at the -- in the back-up in

61. Here's a test where it shows the impact of the water chemistry, and the fact that this is up at 400 millivolts, 4M sodium chloride. You can see at the lower left, that you do get crevice attack, which is what you would expect, but without the crevice, you can see normal stress strain behavior.

If you go to 63, this is one I like particularly. This shows slow strain rate test, with and without inhibiting ions. And you can see -- oh, this one, excuse me, this was just without inhibiting ions, the next one is with and without.

Here you can see the impact of the voltage, and these over here on the right are the open circuit potential, and 100, 200 millivolts. As you get up here, 400, 300 and 400 millivolts, which is really driving it, as Dr. Sridhar said, you do see some crevice corrosion and lose of ductility.

The inhibitor effect as shown on the next chart, if you look at the extreme right, you'll see the case where you have a basic saturated water at 105 degrees centigrade. If you remove the nitrate, you can see you get just a small deviation, a slight movement to the left.

Instead of the nitrate, if you remove the sulfate, you get again another small decrease. But if you take away both the nitrate and the sulfate, you can see that you readily get crevice attack. So that's pretty dramatic.

Now, one of the other things that we've just done, and it's in your packet as a loose hand-out. This is a test we just did last week. This shows alloy 22. This is indeed a slightly more aggressive test, because it has a lower strain rate. This was at 95 degrees C, and we're comparing the room temperature air test, which is the red curve, the one to the left here, with the 95 degree C one percent lead chloride in the ionized water. So there are no buffers in that particular test, and you can see there's no degradation of crevice attack.

So let's go on to the concerns. I think I've addressed most of these, that crevice corrosion susceptibility may develop over a long term, but due to slowly increasing corrosion potential, coupled with the potential loss of passive film protectiveness. And crevice corrosion may be impacted by combinations of aggressive species and concentration of heavy metals.

Our path forward, as we've covered I think already, we're going to continue these separate effects tests. We're going to look at the damaging species of potentially chloride, fluoride, and possibly sulfate from the potentially beneficial species, the nitrate, carbonate, silicate, and possibly sulfate.

And also going to be looking at these different waters; pore water, perched water, and ground waters have somewhat different ionic ratios.

We're going to continue the long term electrochemical potential measurements and determine the critical crevice potential in these environments containing the heavy metal concentrations, and you've seen an example of that.

So that's about path forward for the localized corrosion. Now, I want to get into long term passive film stability and then stress corrosion cracking.

As noted by Dr. Sridhar, alloys, such as alloy 22 rely on a stable tenacious oxide film to enhance corrosion resistance. Limited evaluations have been conducted, as I indicated by atomic force microscopy, to understand the nature of the passive film.

We did basically extrapolate the data that we had from the two year tests in the long term corrosion test facility. And we've done some limited evaluations of Josephinite, which is a nickel iron alloy -- excuse me. A mineral, it's a natural mineral that has survived for thousands of years in stream beds.

The concerns here, as I've mentioned previously, certainly we need to have an understanding of the stability of passive films over very long times. That does not exist right now, particularly the effect of dissolution and diffusion processes.

We need to better understand the impact of aggressive species and mechanical damage. And lastly, we need to understand the mechanical strength and adhesion of the growing film over time.

So how do we hope to get there from here? Well, one of the first things that we'd like to do, is this potential pH diagram for the multi-component, alloy 22 system.

And we'd like to do that, as indicated here, in Yucca Mountain bounding environments and temperatures. And the calculation is analogous to a phase diagram calculation, so that we'll determine the thermodynamically stable fields, which include oxides, soluble ions, sulfides, et cetera.

And we're going to look at, in addition to alloy 22, some of the other alloys, such as alloy 59 and 686.

We're going to include radiolysis effects. Principally by looking at the peroxide impact and also oxidized anions. And look at sulfur effects in our microbial studies.

We're going to continue our evaluation of Josephinite as a natural analogue, and we're going to utilize two computer codes, one is the FACT code, as indicated here for this analysis, which we'll corroborate the results obtained by our qualified THERMOCALC Code, which we have been using on the project.

In fact, the FACT code has been utilized as well by Lawrence Livermore, and they have a lot of experience with that.

Our next chart indicates some of the testing. We want to grow thicker films at higher temperatures, using autoclaves, humid air, and electrochemical techniques. Basically to accelerate film growth for compositional and structural studies.

And we want to understand better the kinetics of film growth. This is very critical. Is it logarithmic, parabolic, or higher order? Does film growth become linear as it thickens, for example? And does the film become mechanically brittle and spall off?

So those are the things that we want to determine by some of these tests.

We're going to use a battery of microanalytical techniques as indicated here. I won't read them to you, but basically, that will help us to understand the properties and characteristics of the film, as a result of the different environments of that we've tested them under.

We're also going to look at corrosion potential changes from some of our corrosion tests. Look at compositional changes in the film over time. Going to look at the film properties of cold-worked materials, and see what the impact there is.

As I mentioned, we're going to perform some additional, but limited examination of Josephinite and other natural analogues, as received and after exposing to selected environments to compare that with the performance of the alloy 22 films.

As I mentioned previously, we're also going to look at some of the other engineering alloys that have longer term experience, such as alloy C-4 and alloy C-625.

So that basically is the path forward for long term constant film stability.

The last area is stress corrosion cracking. And as noted, stress corrosion cracking needs three elements basically. It has to be susceptible, the water chemistry must be aggressive, and a threshold stress level must be exceeded.

As I showed, we have significant amount of U-bend tests in alloy 22, which did not show any stress corrosion cracking after two years of concentrated J-13 waters under acidic and basic conditions.

We have found stress corrosion cracking in laboratory tests that use aggressive solutions. And I think as Dr. Staley and others have said, if you have aggressive conditions, you can crack most materials. The question is, is that a reasonable environmental scenario for Yucca Mountain, and that's something that we're going to have to show.

But in order to eliminate that, at least for the latest total system performance assessment, we assumed that aggressive solutions would develop, and then we looked at stress mitigation as a way to eliminate stress corrosion cracking.

So given the last bullet, the rates of crack growth are relatively rapid, and I have I think the back-ups here.

This shows the GE and Lawrence Livermore test data that I mentioned earlier. And you can see perhaps, I don't know if you can read it there, but the rate here is one point four-tenths into the minus eight, and for the Livermore test, it's around two to four-tenths into the minus eight millimeters per second. And certainly these are very low rates, but as Dr. Sridhar, when you're dealing with repository time frame, these are really unacceptable.

So what we need to do is look at stress mitigation, and as we mentioned, we have two techniques that we're evaluating, laser peening and induction annealing. And I'll talk a little bit about those in a minute.

As far as the model for stress corrosion cracking, we used two models in our total system performance assessment. Basically in the analysis -- detailed in the analysis model report, the film ruptured model and the critical stress intensity model.

And the experimental plan developed the data to support these models. We have multiple test methods that are needed and under way to provide this data. And just as an added confirmation, both the waste package degradation process model report and the stress corrosion cracking analysis model report stated the importance of SCC, stress corrosion cracking, as the container life-limiting corrosion mode. I guess "the" needs to be emphasized.

So we have evaluations underway to determine the stress state through the weld area before and after application of stress mitigation techniques. And these are going on with these mock-ups. There are sections of mock-ups that I mentioned.

Results to date indicate that compressive stresses are generated to a depth of about 2 to 3 millimeters for the laser peening, and up to about 6 millimeters with induction annealing.

And as Dr. Sridhar mentioned, it means that this material must be corroded away by general corrosion, which takes perhaps 10,000 years before you can get to a material that has the tensile stresses that would be required for stress corrosion cracking to be initiated.

We've already done 35. 36, just shows some of the constant load tests. And basically, this gets to the threshold stress requirement, and as you can see here, that stresses that would cause stress corrosion cracking in this material are significant, and much involved what we've considered as a lower level of around the yield strength, or below, as a criteria, so.

As far as our path forward for stress corrosion cracking, long-term corrosion test facility will house our many new stress corrosion cracking specimens. And I guess we have some of those in the back-up. Page 65 shows the Belleville washer test for our stress corrosion cracking.

And the following chart shows a rack, which is basically a replacement rack as we showed previously, which has some of these specimens, as well as these doubled U-bins, which are over here. And we have some compactential specimens here as well, and some crevice specimens, in addition to our standard weight loss, but in this case, thicker specimens.

And so I've pretty much covered the first bullet. The second bullet, environments. We'll have standard environments plus the saturated water and the basic saturated water up to the boiling points. That was one of the reasons for the new test tanks that I mentioned, because some of the tanks we had previously at Lawrence Livermore Lab, it was uncertain whether they could take the 112 Centigrade test that would be required. So we ordered new tanks, which have a higher temperature rating.

Metallurgical conditions as indicated there; base metal, aged metal, weld metal, and welded plus aged materials will be tested. We'll do periodic examinations as we've done with the other long term corrosion test facilities, beginning in about six months after exposure.

As I've mentioned, we've gotten electrochemical tests that are underway. We will be determining the repassivation constant needed for the film rupture, SCC model. We'll continue the General Electric constant load crack initiation tests in these different waters, to determine the stress corrosion cracking initiation threshold stress.

And we're going to continue the reversing DC, direct current potential drop, crack propagation rate determinations at GE and Lawrence Livermore, and a variety of different environments and metallurgical conditions.

And as indicated, we'll perform some select DC drop tests under electrochemically polarized conditions.

And as was suggested by Dr. Joe Farmer, acoustic emission is a technique that might prove useful in stress corrosion cracking to follow the crack growth over time. I've done some experiments using that technique with cracking of ceramics and it's a very useful technique.

To summarize and conclude then, we have experimental results from the current testing program. These were described briefly.

Alloy 22 has continued to perform well, under the conditions expected at Yucca Mountain. Concerns regarding the environment, general and localized corrosion, long term passive film stabilities, stress corrosion cracking were identified. These concerns address aggressive, but unlikely environmental conditions, as I have shown.

And I've described the path forward to resolve these concerns, and reduce model uncertainties. And these include a sweep of new long term corrosion tests, as well as short term tests, using that battery of standard analytical methods that we have available at Lawrence Livermore, to better understand the degradation mechanisms.

I'd be happy to entertain any additional questions that anybody has.

MR. WYMER: That's a lot. Are you still --

MR. STAHL: Still awake?

MR. GARRICK: Yeah. I'm curious about, I guess, the trade-off between research or tests to establish the range of environmental conditions versus the -- how far you need to go with the waste package corrosion tests.

MR. STAHL: Sure. Well, we've recognized from day one when we started the corrosion testing program, that we were behind the eight ball, in the sense that we had to come up with some environmental conditions in advance of the insitu thermal tests that were evaluating some of the geohydrology and water chemistry.

So we've done our best guesses on what we thought those water chemistries could be. As we may here tomorrow, there is effort underway to look at collected waters that we've sampled or are sampling in the drift scale, either test is a function of time.

And what we've seen so far, is that you do get regions where the CO2 basically in the water is boiled off, leaving less aggressive conditions. Some of that CO then gets sucked up in cooler regimes outside of the waste package, so that the pH of those region goes down to I think the eight-sixish or thereabouts, and so you have this halo effect around the waste package.

And then, of course, you have gravity that works for you. Any water that gets moved out, hopefully will then drain between the drifts, and that was one of the reasons why the repository design was changed, to expand the different -- the distance between bore holes, so that you don't have overlapping thermal zones, and you have regions where you can't have drainage.

So certainly we don't have the final answer on the water chemistry if that answers your question, but we've had to move forward, and of late, as you know, we've had modification of the program to look at some of the potential effects of the heavy metals, and you've seen some preliminary results that we've obtained. We will be continuing that with a variety of different waters, lead and other heavy metal concentrations to determine the impact on corrosion.

Does that get to your question?

MR. GARRICK: Yeah. How are you bringing your results to bear on the most current performance assessments?

MR. STAHL: Well, we continually have interaction with them. We are working, as you know, on the TSPA SR.

MR. GARRICK: Right.

MR. STAHL: And all of the data that we have to date, has been put into the models that we have. Certainly if we get some new data that's going to impact the result, then that would be a reason to modify the TSPA, but so far, we don't have any surprises. So that would be the process for modifying the performance assessment.

MR. GARRICK: One of the things that you've covered in a lot of detail is information about getting a better handle on protective films, --

MR. STAHL: Yes.

MR. GARRICK: -- layers and what have you. And a couple of years ago when we had the working group, we were reminded of the possible, very favorable impact of secondary products, in terms of providing added protection.

Where are you headed with that? What are you on to demonstrate?

MR. STAHL: Well, certainly as I indicated, when you have a J-13-type water, we do have inhibitor ions that certainly enhance corrosion resistance. You also have the silicate, which is a plus and a minus, because it tends to code out some of our testing samples, and so people will say, well, maybe you need to eliminate the silicate. But we do have silica in J-13, and so that's going to be a specie that would be present, that we need to look at its effect, whether it's a positive or a negative.

MR. HORNBERGER: First of all, can you lead me through the logic that would suggest that the waters that you can squeeze out of the rock are more likely to be those that you should consider to be in contact with the waste relative to perch waters?

MR. STAHL: I think frankly they are less likely, but that's my opinion.

What happens when you dry the rock out, is that, most of the species that are in that water will remain in the pores. The water itself will diffuse to the fractures, and then vaporize and move out to the cooler regions.

When that water returns, it will return mainly by fracture flow, that will pick up only those minerals that were present in the fractures. And there's no way for it to pick up the residual minerals that were in the pores.

So my feeling is, is it will be more like a J-13 than a pore water, that the package would see.

MR. HORNBERGER: So why are you doing

experiments with pore water?

MR. STAHL: Because, sir, those people who argue that you have the potential for pore water chemistry, and we have not been able to completely rule it out, and hence, we rule it in, and we do some tests.

MR. HORNBERGER: Okay. Dave, I don't know if you have your slide 36, page 36 handy, but --

MR. STAHL: Sure.

MR. HORNBERGER: -- I don't think that I follow the message that you wanted me to take away from that. It's on the stress corrosion cracking that caused the --

MR. STAHL: Yeah. This is the -- having to do with the minimum thresholds stress. And Jerry Gordon's back there, and perhaps to expand further on this.

But basically what we're showing here, is that we don't get stress corrosion cracking until we have about 1.8 times the yield stress, which is much higher than what we see for other materials. For example, stainless steel, you see something as low as 20 to 40 percent of the yield strength, where we start to see stress corrosion cracking.

MR. HORNBERGER: So I'm to take, for example, your pink square, which is C-22 as received, that's your 1.8 stress ratio.

MR. STAHL: Uh-huh.

MR. HORNBERGER: And because it failed at 16:00

hours, that indicates --

MR. STAHL: No, it's unfailed.

MR. HORNBERGER: It's unfailed?

MR. STAHL: You're looking at the 1.8 at 16:00 hours?

MR. HORNBERGER: Yeah.

MR. STAHL: That's as received. That's unfailed. That has not failed yet.

MR. HORNBERGER: Okay. So tell me one that indicates stress corrosion cracking.

MR. STAHL: No, no. I'm saying this was the minimum threshold, we think it's above that. We're just saying because we tested at 1.8 and it did not fail there, that the threshold is above that limit.

Anything else from that, Jerry?

MR. GORDON: That's the main point.

MR. HORNBERGER: Okay. So I'm not going to look at the three plus signs up at 2.4.

MR. STAHL: Uh-huh.

MR. HORNBERGER: And it says above that, one unfailed. Why are there three symbols there and the sign says one unfailed?

MR. STAHL: Yes. These are stainless steel.

MR. HORNBERGER: Yeah.

MR. STAHL: Two of those have failed at that level, and one is still ongoing.

MR. HORNBERGER: Oh, I see, okay. I think I have it now. Sorry.

MR. STAHL: No problem.

MR. LEVENSON: Well, one question as a taxpayer.

MR. STAHL: Sure.

MR. LEVENSON: Are you giving any consideration to using all of the surplus nickel from dismantling the diffusion plants to make these thousands of tons of containers?

MR. STAHL: Yes, absolutely. We are looking at that issue, and we presented that, I think, a light paper to Lake Barrett on that subject. I'm not sure where that's headed, but at least we know what it is that we need to do to handle that material. Sue, do you have any other comments on that?

UNIDENTIFIED: That's fine.

MR. LEVENSON: All right. If you are seriously considering it, are you proceeding to make any bad sheets of metal because what comes to you is not 100 percent pure nickel?

MR. STAHL: Well, as I mentioned, we will be doing heat-to-heat variations in our future corrosion tests. We have no plans right now to take contaminated nickel and test it until Lake Barrett or someone else directs us to move forward with that.

MR. WYMER: As you know, the dupe of the understanding you have of pluses that would lead to corrosion, the more confidence will have in your extrapolation to be extremely long times.

MR. STAHL: Yes.

MR. WYMER: And you mentioned several points, corrosion models that you were developing. I think I understood pretty well the corrosion model stress corrosion repair. These other areas that you indicated, like general corrosion, localized corrosion, long term passive instability. Can you say a little bit about what you're doing on those ... modeling?

MR. STAHL: On the modeling, on the general localized corrosion, I think those are generally straight forward, and those are detailed in the analysis and model reports. Those are not like limiting the passive film stability. One is one that needs development, and Dr. Sridhar had indicated one model, which was dicting the ... of point defect model, which we're looking at. There are some other models out there. This is going to take a little bit of time to evaluate and what needs to be done.

MR. WYMER: I was wondering if you were doing something different from what the Center is doing on --

MR. STAHL: Basically, we're -- we have a competitive or compatible approach.

MR. WYMER: Just one trivial point. My recollections of my freshman chemistry are pretty dim at this point.

MR. STAHL: Mine, too.

MR. WYMER: I wondered about the one percent lead chloride concentration. It seems a little high.

MR. STAHL: That is high. Well, that was one that we chose to test as ... mentioned earlier, that's 10,000 ppm. We wanted to see what happened in that particular test. We will be looking at a variety of different concentrations, with and without J-13, with and without some of the inhibiting species, and see what the impact is.

But 10,000 ppm is large, but if you take the J-13, and concentrate it a thousand or 3,000 times, it comes up to what, a couple of hundred ppm's. So a thousand is still well in excess of what we'd expect from the concentrated solutions.

MR. WYMER: You mentioned too that you are planning to do some studies with water that has trace impurities. That's a delicate area for you right now.

MR. STAHL: Yes.

MR. WYMER: What program do you have planned for characterization of the additional characterization of the water for these low concentration of things?

MR. STAHL: Well, we do plan to take, as I indicated, some of the solutions that are made of alloy to us and determine what the heavy metal content is.

MR. WYMER: Just the heavy metal?

MR. STAHL: We're going to do a whole suite of analyses and see what's in there. Basically, as I mentioned, a lot of the testing we had done previously was with a simulated J-13, so it didn't pick up some of these trace elements, so now we're going to go back and do some testing with J-13, and some other natural waters, see what's in there, and compare that with our simulated water, excuse me, to see if there's any differences. We don't expect any, but that's something we need to do.

MR. WYMER: -- with respect to solid phase formation from some of these things that are in the water.

MR. STAHL: Uh-huh.

MR. WYMER: How much -- how hard are you looking at those? What sort of film studies will you be making?

MR. STAHL: Well, as I mentioned, some of the techniques that we have at Livermore, that's available to us, particularly the atomic force microscopy and some of the others that we mentioned, in that -- I don't know if I showed the back-up slide. I kind of went quickly through that. Let me see if I can find it.

Each of those techniques can tell us a little bit more about the character of those films.

MR. WYMER: Are you getting into some speciation work?

MR. STAHL: It would be nice to do that. I'm not sure. Yeah, I think there is one technique that hits on that.

MR. GORDON: David, I think it's on the microscopy, we've got to find the deposits opposition -- (inaudible).

MR. GARRICK: You're going to have to stand up.

MR. GORDON: I'm Jerry Gordon --

REPORTER: I can't hear you. I'm sorry.

MR. GORDON: I'm Jerry Gordon. We do plan to analyze the deposits like calcide and silicates, and the non-remon spectrograph is an ideal tool to do that.

MR. STAHL: There was a chart on that subject, I went through it very briefly. I'm trying to find it. I'm not being successful.

MR. WYMER: You've got something on 45 that touches on it. That's okay, though. I got the answer from Mr. Gordon back there.

MR. STAHL: Okay, very good. Any other

questions?

MR. EWING: Just to follow up on some of Ray's comments. It's very impressive. I think you're doing just about everything one could imagine doing to address these problems. But I've just been reflecting on the role of these heavy metals, lead, arsenic and so on, and --

MR. STAHL: Uh-huh.

MR. EWING: -- if they do have an important role, then this is really a very difficult problem. The PQ36 code that you mentioned using, won't have the appropriate data, and even if it did, coprecipitation reactions would rule that out.

MR. STAHL: Sure.

MR. EWING: The EHpH diagrams that you would systematically develop, really won't capture won't happens with these trace metals. So to help me in my thinking, is there some general sense of the mechanism by which these heavy metals play a role? Is this just an observation from a set of experiments, or is there some reason to expect this to be important?

MR. STAHL: Well, like any of these aggressive species, what we're doing for the most part is interrupting the potential for the surface film to naturally repassivate. Chloride is one that does that for many systems, and I would expect that the lead and some of these others probably play a similar role.

Jerry, do you have any other thoughts on that as well?

MR. GORDON: That is the main --

REPORTER: I can't hear you. Could you please get up to the microphone.

MR. GORDON: That is the potential rule of the species like that, it's presumably disrupt the protectiveness of the passivate, similar to chloride. There are -- there's some indication that a steam generator, nucleoid and vicin L-600 material steam generated lead can displace the nickel in the oxide form.

MR. EWING: What about other heavy metals like uranium, and just thinking about sources of other maybe not so minor heavy metals?

MR. GORDON: There's no data in the literature that I know of that shows ulterior effect to uranium, similar to the lab.

MR. WYMER: The common thread is that these are easily reducible.

MR. EWING: I was thinking about sources for metals, and of course, the most apparent source is a breached waste package. And so my next question is, does the performance assessment look at that type of connection, the breached waste package then accelerating the corrosion rate of nearby packages?

MR. GORDON: Right now, to my knowledge, (inaudible) --

MR. STAHL: I would anticipate that would be a minor impact. We've looked at package-to-package interactions, and I've not seen that it would introduce any of the effects. I think most of the concern for those kind of interactions have been in temperature, because the packets center line or mid-plane is lower than the edges, and you may set up some cells, for example, but we haven't looked at anymore other --

MR. EWING: It may be a crazy idea, but the ground water is the myer source of these heavy metals, and the surrounding waste package is the major source in or I hope this is not an important --

MR. WYMER: We're going to probably throw this stuff around tomorrow morning, too.

MR. GORDON: It would tend to move downward rather than laterally.

MR. STAHL: Yes.

MR. WYMER: Yeah, that's right.

MR. SRIDHAR: Nararsi Sridhar from the Center. Just a point of clarification. The effect of lead is not due to production of lead species to lead metal. ... because based on all the tests that have been done in the steam generator environment, when people have used lead compounds and solutions, and as far as the solution with oxygen, then you are not going to reduce lead in that case.

The stress corrosion cracking has actually ... So it is really not the electrochemical production of lead compound ... lead ..., it's merely the incorporation of lead in the passive ... as Jerry mentioned, as a possible mechanism.

But what is really normally at the .... is exactly the microscopic for that ... mechanism of lead ... But if it is ... species that is effecting, then you would expect oxygen will be beneficial rather than detrimental.

MR. WYMER: Then you would expect the ... driving force for the lead to displace ...

MR. SRIDHAR: Correct.

MR. WYMER: This is a fascinating subject, but maybe --

MR. CAMPBELL: Yeah. Have you guys been able to -- I mean, one of the things about lead is it's everywhere and back for many years, it was a very difficult species or element to measure in the environment as a contamination. If you were synthesizing J-13 type of water with say, ... chemicals, I would bet a dollar to a hole in a donut, that there was ... Have you gone back or anticipated going back and looking at some of those solutions?

MR. STAHL: Well, the J-13 water is fairly old water, so I wouldn't expect the industrial revolution has had an impact on that. But you can get lead atmospherically by inborn particulate.

We are going to look at that as well, to see what the heavy metal concentration is on some of the dust particles that we've looked in and around Yucca Mountain, and some of the ESF tunnels.

MR. CAMPBELL: That's in terms of the natural environment, but what I was also thinking was in terms of your experimental solutions that you use in your test facility, you make those up from reaging grade chemicals, as opposed to --

MR. STAHL: Correct.

MR. CAMPBELL: -- trace element pure chemicals. I can guarantee they've got lead in it at some level.

MR. STAHL: That could very well be. I understand your point.

MR. CAMPBELL: And if you've got archived samples, you could probably go back and get some idea of what those levels were, at least you can see it was an effect at much lower levels than say were done at the Catholic University.

MR. STAHL: Well, we do have the samples of J-13 water that we generated for the corrosion test programs. And certainly, we can look at those synthetic solutions for heavy metal content.

MR. LESLIE: Andy, this is Bret Leslie, NRC Staff. I just would like to re-emphasize that, as part of the issue, resolution process for the near field, we're going to be requesting from DOE exactly what you've just suggested. We're going to ask them to provide those analyses, to put their experiments in a better framework.

MR. CAMPBELL: Thank you, Bret.

MR. WYMER: Jim, did you have a question?

MR. CLARK: Just a quick question. I was curious about the evolution of this whole issue. How did these particular metals come on screen? Was it past experience with the knowledge that they could pose a problem? Is it because they're likely to be in the environment, what --

MR. STAHL: Well, frankly, the issue was raised by the state, and once an issue has been raised, and it's appropriate, then we need to respond. And so we're doing a series of tests.

MR. CLARK: And you are seeing effects?

MR. STAHL: They are seeing effects.

MR. CLARK: They are seeing effects?

MR. STAHL: We have not seen any effects of it in testing that we've done so far. I mentioned the lead chloride test that we just completed last week, plus our examination of the literature. But they have seen such an effect. The Catholic University, as was mentioned previously, under, what we think are aggressive and unlikely conditions.

But we still need to understand what the threshold is, so that we can rule out that issue.

MR. AHN: This is Tae Ahn, ... In the last technical exchange of NRC with DOE, DOE agreed to provide the information and the ... effect. That's the basis of the ... of their concern of the ... container corrosion.

In the last ... meeting here, we had another question raised by other people on the speciation. ... environment and the reactor. The ground water contains carbonated bicarbonate solution. In the reactor, the water is pretty pure, therefore, you could have different species ... lead compared with ... that associate with the ground water. That aspect also needed to be clarified. I don't think we could simply ... at higher temperature in pure water from the ...

MR. WYMER: Thank you, Tae.

MR. STAHL: Yes, we agree.

MR. WYMER: Any other comments before we leave this subject?

MR. ENGELBRECHT VON TIESENHAUSEN: Engelbrecht von Tiesenhausen with ...

REPORTER: I'm sorry?

MR. VON TIESENHAUSEN: ... I certainly applaud that DOE's looking for trace elements in ground water, and I ... variation in chemistry, I presume, and I just wonder, is that going to include trace elements or are you just going to use at major alloy ...?

MR. STAHL: Well, we're going to get the chemistry, the complete chemistry. So we will be picking up some of the trace elements as well.

MR. VON TIESENHAUSEN: And do an aspect analysis to see what's in there or --

MR. STAHL: Well, I'm not sure what ... aspect or atomical absorption or whatever technique we're going to use, but, yes.

MR. VON TIESENHAUSEN: And you're also going to keep track of the mechanical history on these alloys, and start testing?

MR. STAHL: Absolutely. That's very key. As I noted for some of the thermal aging studies, we're going to be looking at as received yield aged worked corroded samples, and follow that as a function of time, so, yes.

MR. VON TIESENHAUSEN: ... like to mention, that you might want to keep track of thermal chemical history ... down to whatever sampling you've got.

MR. STAHL: Good point. I'll keep that.

MR. WYMER: Thank you. Is that the end of it? Okay. John, it's yours.

MR. GARRICK: Okay. I'm going to declare an unscheduled break before the night shift.

(A break was held at this time.)

MR. GARRICK: All right. Let's come to order. The committee member that's in charge of research is George Hornberger, so I'll let him introduce the next topic.

MR. HORNBERGER: Okay. We're now in to prime time. Bill Ott got the key spot on our agenda here. Bill, I understand you're going to go through this, your view graphs here on the research plan and sort of an overview of the -- how you link back into the commission's strategic plan and all.

Some of this is pretty high level, and I hope that the time spent on the slides might be --

MR. GARRICK: Worthwhile. Is that what you're intimating?

MR. HORNBERGER: Be suitable and brief, and not all the lengthy read, but you know where we are on the agenda, Bill, and we want to get to have time to ask you all the questions we need to ask you.

MR. OTT: All right. I'm on. As a preamble, let me start with, everybody's aware we're not talking high level waste, if anybody's looked over from this morning's discussions, isn't interested in our generic radionuclide transport program. This is not the way ... this time.

I also want to thank a few people that helped in putting some of this stuff together. In particular, Andy, he was up working in our staff for about six months during the year, and he had the responsibility to follow along and help us. I sort of stole him from you guys for about a day recently to sit down and actually draft up our outline for this particular program.

Oh, who am I? I'm Bill Ott. I'm the Assistant Branch Chief of the Radiation Protection, Environmental Risk and Waste Management Branch, which has the distinction probably of the longest acronym of any branch in the Commission.

I'm in the Office of Nuclear Regulatory Research, and my e-mail address and phone number are on the cover.

As a matter of fact, there are four major topics in here. The first part of the first two bullets, I'm going to go over the first part real quick, primarily because a lot of it is addressed to our attempt to come to grips with everything in the Commission these days, has to be addressed in terms of the strategic plan.

It is the thing that every staff member is being encouraged to read and to know how their programs fit into it.

When we got to this program planning task, it -- we didn't feel we didn't have any other choice to start from the strategic plan, look for the roots that would justify the kind of work that we're doing and call those out.

In addition, it is becoming very appreco with any organization, to at least try and establish a vision statement for what your organization is trying to do.

Second, the last two bullets on here, I'm going to go through some brief discussions of what we've been doing the last year, highlight a couple of our accomplishments, and a couple of new initiatives, that I think we, in the branch, find fairly exciting, and I hope you will, too, in terms of what you've been doing, and what we'll be doing in the future, and then some recent areas, recent activities in the area of radiation protection and health effects.

Now, the NRC has a vision. The Office of Research has a vision. I'm not going to go into these. I provided them here for completeness, so we'll go on to the next page.

I do want to say one other thing. The Committee has received a copy of a predecisional plan for radionuclide transport research. It was predecisional, and not to be given out anywhere. I'm going to talk a little bit farther about what our schedule is for letting a wider audience see that.

It is a, I would say, a second or third round working graph. It's very rough. It does not have good connection between the sections, because a lot of it's written by different people. I'm trying to give it to you because you might be an hour trying to peruse the program through the various aspects to the final analysis. But it does have the substantive discussion in there of how we're trying to modify the offices' prioritization system. And I expect that's where we'll probably want to spend a little bit of time discussing that when we get to it.

The other reason for our being here, is that we've got some research data coming out. And we have tried over the last year to increase our interactions with the Committee. We've had two instances, where we brought one of our staff in, in terms of whether to talk to you about the slidework that we had going, and we brought in Bill ... and Glenn ... from P&L to talk to you about what we're doing in the hydrology program.

This is sort of the third one, in terms of trying to give you an overview of what else is going on. We are planning on trying to bring about three more presentations to you next year, again, bringing in the investigators, to keep you apprised of what we're doing, so that you have a better basis for making comments in the research plan.

We wanted to give you an early glance of this planning effort. We're not asking you for a letter on the plan right now. It's for your information, for you to see where we're going, for you to make comments about the way we're going when you write your research status, we're not asking for a specific letter back on it.

One other thing I wanted to mention, is the parallel effort going on by the Office of Research right now. George made a presentation of the Rogers Committee in August, as did ... Powers.

One of the interesting aspects of that meeting, was the charge at the beginning by Chairman Reserve, in which he asked three questions, which had not been anticipated before that.

Those three questions involved, are we doing the right things basically; are we funded at the right level; and is the research being done by the right people.

It would seem to me that when you guys do your research perspective, maybe some attention should be given to specific answers to those questions. That was just a slide ...

To begin at the beginning, the vision. We've had this up for a long time, so you all have had a chance to read it.

Basically it says we're trying to develop technical basis and tools -- data and tools to all of the licensing office to do more realistic predictions of facility performance, disposal system performance.

So let's go on to the next one.

As I said to you earlier, the strategic plan has been -- is the ... for the agency right now. The strategic plan is a small two volume document, which essentially identifies strategic goals, performance goals, performance strategies, and performance measures for each of the strategic arenas that the Commission has.

The major ones, the major strategic goals are make nuclear materials safety, and bear waste safety. Those are the main program areas.

In the Office of Research over the last year and a half, or two years, they've been developing a research prioritization system, which has been based primarily on the major goals, which are safety, urban deduction, efficiency and effectiveness and realism, and public confidence. The measures that have very strongly correlated to the reactor safety arena.

One of the things that we felt we needed to do in developing a program plan, is to develop one that's based on the nuclear waste arena, as opposed to nuclear reactor safety arena.

So what you see here, is what we have extracted from the strategic plan, in terms of the safety arena, performance goals, strategies and measures. The main performance goals that we're looking at are maintain safety; make decisions more effective, efficient and realistic; and increase public confidence.

This fourth one, which is unnecessary burden reduction, but if we agreed to a better job on the first two of these, the result is going to be better, in terms of burden reduction.

I'll address public confidence a little bit later, because public confidence is not so much determined in what we do, as much as how we do it.

Strategies for maintaining safety, and these you can get at -- get from looking at the plan, but these are not all the strategies. These are the strategies that we felt directly connected up to the reason for us doing research. And I'm not going to read through these. The strategies for maintain safety, the strategies for effective, efficient and realistic, and on the next page, the last one, is the strategies for increase public confidence.

What's the basis for us doing research? If you ask the licensing office, the primary reason for us doing research is to help them get their job done. And that's true. I mean, that is the reason we exist, and because of that, the user office has a process that's called development of user needs.

In the Office of Research, we give a very high rate to user needs that are identified by the office. How is that company from the strategic plan? Well, it comes from their trying to implement their responsibility in the strategic plan, and noticing programs with the licensing experience through their working with other people, their peers, and identify to us things where they need additional work, to help them do their job better.

If you look at the long term, which we tend to do in the Office of Research, we also tend to look at what are the data that sits out there, and what the tools and basis for the things, that the licensing office uses.

Are there gaps? Are there potential problems that we see developing over the years? Not today, not tomorrow, but perhaps three years from now, five years from now? I think we've had some success in identifying some of those issues, even to the point of time of not having the user office support for doing those things.

We're getting very close to the point to where they are starting to do a lot of these issues. I'll point out a couple of those as we go further through the document.

New information. We tried to keep a close touch of what's going on. There have been four significant reports out of the national cabinet just over the last year.

One we participated in, which is one of institutional control. There was another one on basic research needs in the earth sciences. Both of these were funded by DOE, that address issues that are very close to the responsibilities of our agency. Our staff worked out those things, they looked for new information and processes, things that potentially effect our ability to do a good job.

We tried to address those in the research program, put them on a list of things that need to be addressed further in the future, and I'll get to that list as time passes as well.

If you look at the way we've organized the program, we've talked all this morning on TPA, I was fascinated to see developments and improvements that have gone on over the last year.

(Indiscernible)

I'm actually thankful that I was able to come down here and listen to that, because I found it very interesting. We have the same problem with decommissioning facilities, contaminated sites, waste.

We have to predict performance over time. The time isn't as long, the source term isn't as large. There isn't that much money in the licensing, so there are a lot of differences between what we do for decommission and other types of contaminated sites that can be done for TPA.

We're trying to develop a generic database, look for tools that can be looked at for and develop tools that can be applied broadly, ... and develop, because there has been a focus in our program, in recent years, to develop and some of the developments over this past year have come to the point of looking for and we're looking to places within other agencies, where we can magnify our resources, and perhaps tap into tools that are already available. I'll discuss that later today.

But if you look at PA and you look at how the calculation develops, there are certain elements that are common in the PA source term. You have to identify what kind of waste you have, what the inventory is, what the chemical form is. You have to know something about what you've got, before you can predict what's going to happen to it over time.

Did I go too far? Okay. The performance assessment provides a framework, which facilitates -- let's go on to the next one. Let's just skip this one.

Site storage is one of the things that came to our attention after the institutional control meeting. It had been a concern of ours with monitoring processes and things like that, but there are more things to it than monitoring. Site storage is now becoming a separate ... program, which is separate from PA.

Site storage ... essentially involves after the PA. Inputs from PA help us determine things that we need to do during monitoring, but they are different kinds of things, during site ... Let's go to the next one.

Okay. In terms of the generalized performance assessment, organizational framework. We have -- in terms of work that we've been doing in source term, we've had work focused on solubilities and slag degradation, a very small effort. But one that produced product this year was the licensing office found very useful, that was the work that we reported to you on ... slide work.

REPORTER: Can you get her to turn your mic up just a little bit. I'm having a hard time hearing you.

MR. OTT: Maybe if I just turn. Is that better?

REPORTER: Yes.

MR. OTT: I'm sorry. I tend to be a little soft spoken.

In terms of future efforts, they may include characterization of contaminants associated with entombment. Entombment is a very real issue to us right now. There may be additional industrial process waste forms in non-slags. We don't know, we'll have to look at.

In terms of engineered systems and materials, we've had a very small program going on for a number of years, that's been looking at concrete. It's the main material that's used in a lot of applications for creating covers and creating walls and things like that. That work is nearing an end. There's a model that's been developed for concrete degradation called foresight ... been looking at developing data sets for validation of that model. We're going around the country and looking at structures as old as we can, to get good data points to calibrate that model over a long time frame.

But that's not the end. I mean, there are lots of other materials besides concrete that are being considered for barriers. There are things like chemical barriers that are being looked at by EPA. We have to be aware, in this particular instance, not only of what we think might need to be looked at, but what the DOE is doing and what EPA is doing.

But there's certainly, I think, a need for additional work on the long-term performance of non-concrete engineered barriers, and we need to look into doing that as a future effort.

Transport processes. This has been sort of the largest and single effort in the branch, because it includes both hydrogeology work and the geochemistry work. We're looking at flow through both saturated and unsaturated formations, and those processes that might retard and create ...

We have been looking at mechanistic absorption modeling for, I would say, at least six years. Primarily with the USGS out at Mineral Park with Jim Davis' group, and at Sandie National Laboratory with Randy ... and Hank Westridge.

That work is getting to the point now where a couple of years ago, we decided to do a demonstration project at Nada Rita in Colorado, which is a radium recovery site, which has been remediated by DOE. Everything was scraped off down to the ground table, ground water table, but they still have residual contamination in the ground water table, and a complex chemical environment.

We deliberately selected that, to see whether the information that we had gathered over the years of working on the natural analog at Alligator Rivers in Australia, which Jim felt it provided sufficient data, to be able to actually model a chemically complex site, to see if that was actually possible. He felt that it was, and that uranium was the one thing that he felt that he could do it with at this time.

Sandia has been looking at a little more fundamental perspective, and that lowers the materials on the same problem of mechanistic absorption.

On the flow side, the work has been very much focused on looking at uncertainties. Again, now in direct response to a user need for MSS, was looking at parameter uncertainty and models like REDRAD and DandD. These models that are applied generically to a number of sites, basically deterministic models of when we started with them.

Many questions with regard to those models, in terms of the pedigree assumption, pedigree of constant that were used, we contracted with the AML, RESRAD to take a very strong look at the assumptions in RESRAD. And to make certain that we had a very good pedigree on it, because we wanted to put a problemlistic show around the RESRAD, to allow it could be used for sub-site calculations for the Commission.

PNL essentially helped us by developing distributions for parameters to allow -- provide the data that was needed to run DandD and RESRAD in problemistic mode. You have to have distributions on hydrology parameters, some things like KD's or whatever you're going to use for absorption, and other performance parameters and models.

That work for DandD and RESRAD has been completed. The user guides -- user manuals are getting ready to be published now.

What are we going to do in the future? Okay. We've also been looking in this -- I'm sorry. Conceptual model uncertainties. No, that's the other one. We've been looking on conceptual models ... at the University of Arizona. That's work that was placed under a competitive contract, addressing the question of how we can go about selecting the models that we use, and then if the data -- the interpretation of the data is not unique, there's an alternative interpretations of the model that -- of the data that would lead you to different models.

What's the uncertainty created by taking one path, one set of models as opposed from another path.

Let me go on. Pathway analysis. We're not doing any work on that right now. However, there's some information -- well, there's information. The professionals on the staff in the ... area have been looking at this for a number of years, saying the data in the pathway models are old.

A lot of that data was generated in the '70s or before the '70s. And there needs to be work done to update that information.

The first ever might do in the future is to try to come to grips with that, we just go out and survey and take a look at it, and see how good -- what the quality of that data is, and determine whether there is a real need, where we could actually measure and develop that, we can ascertain that the information does need to be --

MR. GARRICK: Now, Bill, do you think there's enough information available now to do a competent atmosphere dispersion analysis for volcanic ash?

MR. OTT: For volcanic ash?

MR. GARRICK: Uh-huh. You guys brought this back into an important issue.

MR. OTT: We? Not we. We started off there in a number of years ago. In terms of -- I was here 18 months ago when the Center made the presentations on volcanism, after we got the -- I guess you guys came down with your final determination that we shouldn't do anymore work on volcanism.

And after that, being at that presentation, and seeing the levels of risks that were predicted, I couldn't really argue with you, because the levels were at the margin.

MR. GARRICK: Right.

MR. OTT: And to my mind, if that's the worse that you can --

MR. GARRICK: But that's where the analysis is going to come from, is --

MR. OTT: Is atmospheric.

MR. GARRICK: Yeah.

MR. OTT: From the volcanic event.

MR. GARRICK: Yeah.

MR. OTT: I would think that a lot of the work that's been done could be adapted to do that, yeah. That was your question?

MR. GARRICK: Yes.

MR. OTT: The dose assessment term I put up here was primarily to describe the overall codes, the RESRAD's and the DandD.

The biggest effort that we have had going on in recent years, is development of a flexible frame wall.

I'm not going to say a lot about this right now, but it has come to the point where we don't have the resources to do that on our own anymore. And I'll talk a little bit more about this, but we probably are going to stop doing that by ourselves, and join with DOE and DOD and TPA in a joint effort to essentially work on flexible framework.

That's all I want to say about that right now.

Site stewardship. We do have work currently planned to address monitoring. We had done some work on monitoring, shell monitoring, on monitoring, shadow monitoring, a few years back. That work was completed, and we wanted to go down and look at monitoring the unsaturated zone for a deeper systems.

We weren't able to do it at the time. That's the thing that's on the books right now.

In the long term, there are other things that institutional controls reported to the National Academy, said there are real problems with assuming long term institutional control for some of the legacy sites that have to be -- that can't be released for general use.

I think that's something that we need to follow, what DOE's doing, and there may be some role in there for us to do some small work, to either stay on top of that, or make some kind of contribution ourselves.

The next one.

MR. LARKINS: Bill, before you leave that. Your research at one time, was doing some work -- those assessment sets.

MR. OTT: That's what I'm talking about. We can't -- don't have the resources to support that.

MR. LARKINS: Okay. So that's ...

MR. OTT: We're doing deliverable on sets during this month. We were anticipating that we'd have certain capability and ... will be expected, additional ... and we just didn't have the resources to follow that particular avenue anymore.

When we first began that effort, that was also a multi-agency effort with both DOE and PA. Over the years, they both pulled out, and we tried to shoulder the entire burden ourselves, and it has become too much. We can't do it anymore.

There's also promise that -- by changing course, we may get a lot of the things that we were trying to develop a lot sooner, and that's a site benefit that -- you always make changes like this reluctantly.

MR. LARKINS: The consensus is that it has more of a problemistic --

MR. OTT: Well, there's problemistic techniques in SAD's have been taken over into those RESRAD and DandD. But they're problemistic versions of RESRAD and DandD available right now.

And in terms of accomplishments, I'm going to go over that in a couple of minutes.

Prioritization. The topic that everybody likes to look for.

Prioritization system in the Office of Research is strategic plan based. It's analytical hierarchy process based. Basically that means that the analytical hierarchy process was used to develop the priority system. It's a rating system, developed from a analytical hierarchy model.

Okay. The measures of the original system were structured around the reactor safety arena. They included measures that we had -- we are projects that we get, which included things like core damage frequency and large early release fracture.

It becomes difficult, and it's one of these classic situations of comparing apples and oranges, when you have to compare the apple by saying how much like an apple does it taste. So it becomes difficult to compete for resources, in a situation like that.

We're proposing to change that, to make those basic measures relate to nuclear waste, so that we can compare regarding safety, as it's viewed in the ... as both to safety as its viewed in the reactor.

We don't expect the overall system to change. When we talk about and developed the changes that we're proposing to make, we deliberately did it, so that we wouldn't .. the ... system, primarily, because we thought that was the path of least resistance.

Next. Now this on the left is what the Office of Prioritization of the system looks like. And you'll notice -- okay.

The first criteria here basically is a no go. It says -- it does issue a credibility, or varied sources of credibility, and even here, there were things to talk about operating experience, and technology and ACRS, which were blatantly not right, so we've got ACMW in there, all right.

But we also said, hey, let's look at regulatory -- regulators that we're talking about, about waste disposal and contaminated sites, okay. The MC's are no changes, we wouldn't change the rest of that.

Formal user needs, Commission SRM's, these are things that essentially drive our existence. Use our office once something, we try to be responsive for the Commission says we do something, we don't try, we just do it.

Safety significance. This is the first place where we have deviated from, the office system, because if you look at the way systems are evaluated, and their safety significance, it doesn't leap out at you, when you say it addresses new safety challenges, maintains or assures current level of safety and monitors safety performance. Because the measures they use to judge this relative values are CDF's and work, core damage frequency and large ... release ...

Said, well, this doesn't work for us. What are the appropriate measures here. And if you go into the predecisional report that I've given you, there's a description of the way this is done for the waste. At least now, we're looking at whether the regulatory requirement within the waste agreement. And that basically goes back to 20.1301 of the hundred limit that you were talking about earlier today.

We also talked about putting in things like addressing technologies to prevent degraded isolation performance and addressing monitoring long-term care.

The scope of licensees. We didn't change that, except to say, let's talk about a class of license. Let's talk about decommissioning. Let's just talk about slag sites, as opposed to talk about PWR's and PWR's.

Again, we tried to be -- go ahead. Realistic decision making. ... large nuclear industry out there that supports a significant amount of work themselves.

The decommissioning licensee arena, is not what you call a wealthy group that supports a lot of independent investigation.

Okay. That's right. So in terms of -- I can't go out there and find 50 decommissioned licensees that are running a research program, including 50 percent of the project, and join them for leverage. All right.

So in this particular case, we said, let's generalize this. Let's stop talking about licensees and this kind of stuff. Let's talk about partnerships. So we just changed this to say, hey, if we can partnerships with other federal agencies, other national governments, that stuff, we ought to get some kind of credit for this prioritization system. And so we just proposed doing that.

The next one. Burden reduction. Again, the ... looks at doing things like changing something out of one reactor that saves $10 million in a given reactor year, and we'll save them $100 million over that year.

Again, we're talking about decommissioning sites, contaminated sites, sometimes we don't even know who the owner is. It seems unreasonable to try and justify a program, which needs to be done, based on those kinds of measures.

We said, okay, let's look at it in terms of cumulative savings, you know, not savings per year, savings -- but cumulative savings, because something's going to save the decommissioning industry $10 million, we ought to get some credit for that as well.

Those are no public ... contributors. Originally, this prioritization system had something in here on corporate ... I think in the last iteration when I wasn't around, it was ... office, they determined that public confidence really is something that comes out of how you do your work, not what you do. So it wasn't determined to be the thing that -- a primary factor in prioritization projects ...

We don't suggest changing that. And at the bottom of that table, it tells how the scores are created. And what the office does, is take this rating scheme and evaluate projects and activities, not individual projects, but projects and activities. And then within those activities, there may be several projects.

They score them, they create a big huge list. And they go down to the bottom to where the budget is, and draw the line. So that tells you how it's done, and this tells you what we're trying to do to change it to make the process at least more reasonable for us to be looking at for resources.

Now, this is the last page of this section.

No. Implementation. All right. This is the last one. How are we going to move forward from here?

We've got a very rough draft. We want to clean that draft up and by the middle of December, essentially send it down to the user office, NMSS, and over to NRR, to get comments and inputs on the plan. That will include Section 6.

I have not talked about Section 6. Section 6 is the detailed listing of current projects, and proposed new projects that we would anticipate looking at over the next five years. ... release handy right now, we've gathered a lot of information from the staff but I haven't had a chance to put it all there.

The part about current ongoing work is relatively complete, and includes a brief scope and brief objective and short statement scope of the projects that we have ongoing. That's all included in the predecisional draft that you have, as the last section of the report in the plan.

Okay. We want to go NMSS and NRR, ACNW. We would like to incorporate ACNW ideas, but we're not going to ask you for a letter. I don't want to put the extra burden on you guys in reviewing a report that's really in draft form.

If you have ideas, if you want to look at

Chapter 6 and say, are there things that I think they ought to be doing over the last five years, we would welcome a note, an e-mail, whatever from you, suggesting topics that you think we ought to include in this plan.

I want to give you the same admonition I gave to the staff, we can't approve a ... Okay. We have staff that ... to put those into the plan.

Next page. After we get internal refunds, after we get NMSS' reaction to collenate their views, put ideas that they're suggesting for participatory research into this, we would like to solicit information from a larger audience.

Those are our partners in other federal agencies, we have MOU's with several, and ... that's fairly exciting.

... comment, and we'll give people 45 to 60 days to suggest ideas. When we get all that stuff back, we'll create a final document, we'll create a final listing, and we'll go through there and we'll try and develop a prioritization plan for what we would executive over the next five years, in order of decreasing importance, or decreasing ... rating system.

Now there are constraints that may be applied, things like balance. You can't say that well, I've got $15 million worth of hydrology research, so I'm going to throw this hydrology. It came out .01 points in the rating system in geochemistry.

MR. HORNBERGER: It sounds fair to me.

MR. OTT: I don't readily agree with you, George. I think we do have to maintain some balance and advance along the front, to try and maintain the evolution of these tools in an orderly manner, as opposed to just approving one thing at a time.

All right, next. All right. We're done with the plan. I deliberately didn't go through Section 6. I didn't want to waste a lot of time going through that topic.

What I'm going to do now is talk about -- I think I'm listing six accomplishments over the last year, and go into a little detail.

One of them I've already mentioned, a slag report that we've put out in March, and you heard the report on. We got very good reactions on that from NMSS. We anticipate finalizing that report in the next month or two, including a multi-compliment PG model.

We had a review of hydrogeologic programs, with a lot of attendance from other people. Again, we noticed it on the website, and made it a public meeting and we invited everyone to come that we could, and that was the one that we scheduled deliberately in conjunction with your meeting, so that we could hold over the investigators and talk to you.

But at that meeting, we had USGS, we had someone from the NWTRB. We had someone from -- we had numerous NMSS staff present. We had people from the center there. We had DOE. We had ARS, EPA, National Academy's, the State of Illinois. Okay. I mean, all those people came to that meeting, and we were very happy to have that participation.

We've been opening our program reviews. We've been trying to have multi-project reviews, when we have light projects, to have a program that's going to last a couple of days, to get into enough depth to attract our counterparts from other agencies. We've been doing this for about two years now, with a big success.

We're very pleased with the response we have on this one. Others, we've not had as much participation, and we need to find ways of getting more attention for that, or getting a bigger audience somehow.

I mean, the public ..., we attend corporational meetings, we publish a period a new journals, but somehow we have to engage other state ... more efficiently.

And primarily, the most effective engagement would be for federal agencies, like DOE and UPA and the Department of Defense. The Department of the Army is the one we're working with right now.

We have a workshop on multi-media environmental models and ... in March, which was also a very large success. That meeting did have participation from the department, the U.S. Corps of Engineers, the Environmental Protection Agency, and the U.S. Geological Survey were all there, as well as the Environmental Protection Agency.

Next. About six weeks ago now, the EEO signed the international agreement, which essentially, makes us a participant in the OECD/NEA absorption project, phase two. We were also a participant in phase one. We were a late entrance in phase one, because we hadn't heard about the projects inception.

We learned about that through a meeting on another international project, and decided this was something we needed to be a part of, we needed to keep up with what's going on in the international community in absorption.

We completed the problems ... of RESRAD and DandD, which I've already mentioned to you. And we're currently developing a NOMU with a research on PADO in the Department of Defense, in this case, the Corps of Engineers, at the Water Waste Experiment Station. USGS has learned of this particular effort, and has asked if they could participate as well, and we also helped to get the Agricultural Research Service in, because of their expertise in the area of soils.

So we hope within the next two months to have an NOMU in place that will facilitate both the exchange of information, and the development of things like joint workshops with those five other federal agencies, particularly their research arms.

Next. I'd like to go into a little bit more detail on the OECD/NEA absorption project and a little bit on two of the others.

The objective is to demonstrate the effectability of different chemical ... modeling approach to support the selection of absorption parameters for performance assessment.

The conclusion of the absorption project, phase one, was that the state of science is to the point where we can do a better job in KD's. It might be an informed KD, one which is selected as a result of another processor off to the side, which is considering things like pH and eH bionitics ..., but they felt that it was time to -- it was time to try applying that. And the second phase of the absorption project is essentially going to do that.

There's an executive group that's looking at test cases. Each participating country and there are 10 countries participating, and 13 organizations.

Each country is going to supply modeling changes or test cases that are developed by the technical direction team.

The NRC is going to have three teams working on the project, three modeling teams; one based here at the Center; one based up in Rockville with MNSS and RES staff, and one with AUSGS contractor out at Mineral Park. So we're -- we're actually very pleased in this instance that we went to MSS and we invited them to join and they saw a value in the ... capabilities of their staff and the final analysis of applying their expertise to various problems ... to the results of other teams, and so we decided to join with us.

You can go on -- I think there's two parts down there. There are more details here that you can look at if you want to.

I talked about DandD and RESRAD. DandD have been a much more ... code, particularly in version one. This is a set of calculations that we did to try and compare RESRAD and DandD in their new versions. These are now problemistic versions and one -- I think we ran a thousand realizations for DandD in these calculations, and 500 for RESRAD. It could've been more for RESRAD, I'm not certain. It was at least 500.

The comparison here was to go back to some published information, in terms of places where people have concentrations and doses, to see whether -- how RESRAD and DandD would do with those published values, and in comparison with each other.

What applied here, and my note down at the right says, "90th quantile". These are 90th quantile values.

I deemed the Indian minus -- I'll explain that in a minute, RESRAD, RESRAD*, and then DandD, RESRAD, DandD, RESRAD, for U-238, ... testing and K-40. The reason there's a lot more runs done for potassium 40, because it turns out that fish pathway in the residential scenario, tends to get a huge dose. That's because the residential scenario assumes that the person residing on this site has a pond, and eats something like 50 kilograms of fish a year that he grows in the pond. And that pond is simply contaminated by waste or things that were left on site.

We're separately looking at that assumption, in terms of consumption of fish, and whether there's anybody with an agricultural ... site and ... likely to consume that much fish over a year.

But for this exercise, we decided to run DandD without ...

RESRAD had a similar quirk in it, and the drainage area was much, much larger than the contaminated area. And so we ran the RESRAD the second time, we shrank down the drainage areas, the contaminated area, to try to get some comparability out of it.

I mean, when you look at the numbers in this table, potassium chlorine, ... 233 and 238, we feel that they're remarkable ... in terms of the relative magnitude of these projections. You wouldn't expect them to be exactly the same. These models are significantly different.

But the old problems of DandD's way over the conservative; RESRAD is the greatest in there. They hover around the same values on these things. Sometimes one's a little higher, sometimes the other's a little higher. And they're both hovering very close to what UNSCEAR reported in terms of data -- in terms of doses from natural concentrations of ... uranium and potassium.

Next. The research MOU that I talked about, developing media meeting on linkages in March gave rise to a lot of discussions of the participants in that meeting. And the idea popped up that, you know, wouldn't it be nice if these groups got together and interacted more.

And it also turns out that DOD, EPA and -- or excuse me, DOE, EPA and the U.S. Army Corps of Engineers are the primary supporters for the frame network at PNNL.

That is most likely where we are going to go for large site complex modeling expertise, after this. We have not yet placed a contract there, but all indications indicate that that's where we would go. The framework is already up and running.

There are already significant capability both with NEPA and the Corps of Engineers, and then DOE. One of the things that -- when we met a couple of weeks ago to essentially make certain that applications using the frames model that we're currently diverging. In other words, they were winding up having multiple versions of frames. They didn't want that to happen. They wanted the framework to converge, so if there was a single framework, that all of these particular modeling applications were working off of.

Ralph Katy and I went out to PNL and participated in the meeting, and they were discussing what they were going to do over the next 18 months to three years. We found that to be a very exciting prospect, not only from what the frames will be able to do, if the capability that are brought in by places like the Water Waste ... Station, ... models now, but they have an extensive modeling system, that would be a great value to us if we were together.

They also have a system that is designed to look at general calculations, and in fact, they're using ... statements that proves output to satisfy the requirements of those determinative impact ..., so we're hoping to get access to that kind of capability through this partnership.

We made -- we've had numerous teleconferences with regard to this MIU discussions with the appropriate staff at the four agencies.

We've had OGC review and at least three of the agencies are holding ... approval from Portland, until we've got the legal approvals, and we hope to be able to move forward with this in the next month to two months. I would like to see it happen by Christmas, but I'm not certain.

Next. Now we're going to switch tracks. We're going to leave radionuclide transport. You guys wanted to hear about what's going on in the other side of the house, so we're going to talk about that a little bit.

We'll start with the technical basis for clearance. There was a contract awarded about a year ago ... procurement providing technical basis for rule making on the control of slightly contaminated materials.

Because of concerns that arose after the award, the contract on conflict of interest, it was decided that the contract would be rebid. That bidding process has been gone on for a while. We expect a contract award in January. It's still in the procurement process, but we expect to have that completed by then.

The National Academies effort. You made -- you eluded to earlier in one of the letters that you were working on yesterday. The -- it's called the Study of the Alternatives for Controlling the Release of Solid Materials. The contract was awarded on August 31st. The duration is from September 1st, 2000 to February 28th, 2002, provision committee membership was posted on the web on November 9th, I believe an 18-day comment period or something like that.

We have met with the National Academy staff, specifically on October 24th, to provide documents that are called for in the contract. There were a number of documents that were discussed, and or in this area of background ... and we met with them and provided them with that material.

There is a tentative date for the first committee meeting has been proposed, for January 3rd, 2001. So that's the status of what's going on with the National Academy right now.

Next. This should be dear to the heart of our Center. We contracted with them to do a review of the drafting of 1640. 1640 was produced by the same contractor that had won the award on the technical basis contract. There was some concern that if people worried about conflict of interest and maybe 1640 would be tainted.

So we contracted with the Center to do an independent technical review.

The bullets here are semi-quotes from their report conclusions. Found that SAIC agent -- SAIC was a contractor generally performed a high quality analysis; the QA program was appropriate and effective; they identified some minor errors that should be corrected; and they proposed additional scenarios for future work.

1640 will be reviewed, revised appropriately and then published some time in the next couple of months.

Publication of draft NUREG 1725, human interaction with reused soil, a literature review. We published a literature review, which caused no end of public comment. We contracted with the Agricultural Research Service as probably will be the people that would know the most about soil in the country to contract ... just give us an idea of what people use soil for, so that someone could then assess what the impact would be, if you were releasing slightly contaminated soil.

That's been published. It was out for comment. The comment period closed November 17th. ARS and NRC staff will address the comments and decide whether to include additional sources in the list of sources that was provided as a result of the literature here.

Next. We'll move on to the health effects area. One of our major efforts is BEIR VII. That's a multi-agency effort with a primary funding coming from EPA and DOE.

It was originally a 36-month study that was initiated in September of '98, with a September 01 deliverable. It's been complicated by the fact that there's an ongoing revision of the atomic bomb dosimetry which won't be available until 2002. The atomic bomb dosimetry is one of the bases for the report. They are proposing to delay or extend the project for two years.

There has not been a final decision on that yet, but there are proposals before the various funding agencies with regard to doing that.

The JCCRER, which is the work that's proceeding to examine the occupational exposure database for workers in the Mayak production facilities in the Soviet Union.

We're in the third year of a four year study at the present time on pulmonary effects in Mayak workers for prolonged exposure to plutonium.

Developing an integrated database of clinical and dosimetric information. They basically have 40 years worth of data on about 400 workers, who were employed at the Mayak facilities. So we've got both detailed clinical data, and detailed exposure data from the facility itself.

MR. LARKINS: Bill?

MR. OTT: Yes.

MR. LARKINS: I've got a question here. How come there's no ... at Chernobil information and put that as part of your --

MR. OTT: I don't know the answer to your question. This stuff was all started in the health ... branch before I took over, before the two branches got merged.

MR. LARKINS: Well, I was just curious. I mean, it's an obvious --

MR. OTT: I think there's a lot of stuff going on in Chernobil, but we're not directly involved in any of it right now.

ISCORS Sewer Study, and this one that we would like to come to you in late summer to talk about.

Sampling is complete, 50 percent of the samples have been analyzed. They expect to be complete with all of the analyses by June. We're looking at coming to AMNW in late summer. ISCORS website, I've listed the website here. There's a lot of information on the study under the website. All you have to do is allegate it to get to it.

They're basically looking at the collection of radioactive materials and hospital wastes and things like that and sewers, and trying to determine whether it constitutes a problem.

Revised MARSSIM manual published, we're a participant in that. That's also available on the EPA website. That's it. That's it.

MR. HORNBERGER: Bill, I --

MR. OTT: ... handed in it.

MR. HORNBERGER: Bill, I have a couple of questions and they're probably linked. Let me -- it'll be a relatively long question.

As you know, when we commented on the research effort, the Office of Research effort for the past two years now, and our criticism, if you like, were sort of two-fold. The first one was that we didn't see the prioritization scheme that we thought was necessary, and linked to that, we said that the prioritization scheme, we would like to see linked into more strategic overview of what needed to be done.

And then linked to that, we were concerned about whether or not the budget was of the appropriate size to really do the work, whether it was above critical mass.

Now, I think that everyone must be really impressed with what you have presented today in terms of a prioritization, in terms of thank you for sharing the predecisional plan that you have put together.

Certainly, that goes directly to the -- to what we commented on. The question that I have, however, is that the prioritization criteria, to really get you in the game, requires the changes that you went through with us that were proposed. Otherwise, a linked bit, whether or not your program is above critical mass, in terms of dollars really comes around.

So my linked question is, how -- what's your score card in terms of having these proposed changes approved, number one. And number two, how do you think -- how do you anticipate this may effect the overall budget availability for waste related research?

MR. OTT: Okay. First, you had a copy of the predecisional draft, an early copy in your notebook. You weren't supposed to have that.

You weren't supposed to have that because we haven't gotten our office director to approve it. I met with the office director Wednesday before Thanksgiving and went through this briefing, and got permission to give you that predecisional draft. I went over the priority -- changes to the prioritization scheme, and his primary concern was whether it would disgrunt the other party's prioritization process, which is something that we had anticipated and we've tried to come to grips with.

I think that there is going to be support at the office level for that revised prioritized organization scheme.

Now, does that mean we're going to get more money? Not necessarily. It may force a decision with regard to separately funding the major ... It may not, I don't know. All I can do is speculate at this point. I think something that's probably might be a significant factor in this, when we get around to budget time this year, is the kind of remarks that the advisory committee has come out with.

Those questions that Roger's asked. I mean, is the work that we're doing good work, regardless of whether it's highest priority work, is it work that you think needs to be done.

One of the things that has both the Environmental Protection Agency and the Corps of Engineers excited about this NOU, is access to the work that we're doing on parameter and model certainty.

They find the work that we've been doing in that area to be extremely appropriate, even for their concerns.

It is actually kind of gratifying to go to a meeting and find out that your sister agencies are seeing you doing things that gee whiz, you know, we really like what you're doing there, we'd like to get access to it.

But to go back to the reports that come up, very seldom does a clear statement come through from the Commission that the work that we're doing isn't a value to the program.

What comes through is problems with the prioritization and things like that. It would be nice to have clear statements with regard to, is the work that you're doing viable.

We're coming to the -- to a near term conclusion on the geochemistry work. We've actually put a lot of resources into that over the last, not just six years, but probably longer than that, because we started doing it in the high level waste program.

We originally funded work at Alligator Rivers as a natural analog to uranium and ... waste issues. We did work at Pena Blanca with the Center for the same reason in geochemistry.

So if you looked at the cumulative investment of our knowledge over the years, we're now getting some kinds of gratifying results in seeing the international community coming to the same conclusions as we are. The information has come to the point where it ... as usual.

It's not just information. It's also the technology that uses it, computationally.

When we first started this, it was not feasible to do anything but use a constant KD. The computers -- the computer ... couldn't handle it, but computers have increased a lot in the last ten years, their capabilities now.

And even though it would be more complex to deal with chemistry, it's something that we think is computational feasible now.

So we're seeing gratifying results from external sources, but we're not seeing as much from internal sources that might help us. That's one of the comments that I would make. I don't think your question included the -- included level, whether I thought we were at the right level.

MR. HORNBERGER: Right.

MR. OTT: If you look at what I stated -- I showed you about what we are doing, there are areas that we're not doing very much in at all. We're on a shoestring. The work that we're doing at NIS has been funded at about $100,000 a year. The work that we've been doing on slide, we've been working .... at Johns Hopkins University. We're not doing any work at pathway analysis, we should. We ought to be looking at some of those issues. I would say ...

MR. HORNBERGER: Okay. Actually, the second part of my question, and this is my final question, short answer. Depending upon how we did the counting, and we could never get a total agreement on how one counted, I think that the program -- overall program level was between 1 and $2 million the year before last.

What's your budget for this fiscal year total?

MR. OTT: For --

MR. HORNBERGER: Total program. Has it gone down, has it stayed the same, has it gone up?

MR. OTT: Well, no, what you were talking about probably -- what you're talking about probably isn't total level. It probably -- we adjusted the rating ... that part of it?

MR. HORNBERGER: That's right.

MR. OTT: And I would've thought it would've been listed at about two million. I wrote these things down last year and totaled them up last night. Where's that piece of paper? I thought you might ask that question.

There is. In the waste arena, in FY 2000, the funding was 2645. In 2001, it's 2177. It went down by about a $500,000. But part of the reason for that is both RESRAD and DandD were completed in 2000. And there's only a little bit of money going into finishing over the user manuals and a little bit in training and that kind of stuff.

So the majority of that decrease between 2000 and 2001, is the fact that we considered RESRAD and DandD to be complete.

MR. HORNBERGER: Fair enough.

MR. OTT: In terms of materials, the 2000 budget was $1.4. The 2001 budget is 485,000. The difference there, and that's why it's so dangerous to give out numbers. The difference there is, there's $800,000 in the 2000 budget that was awarded to the National Academy, and that was essentially provided at JGER ... MNSS. Money was moved around in the agency to be able to fund the National Academy.

MR. HORNBERGER: Okay.

MR. OTT: So $800,000 of that difference comes from funding -- all of the fund in 2000. So not much difference. There may be a couple of hundred thousand dollars. And the third area is reactors, and I say reactors, because that's where things like JCCERR funded, the radiation protection stuff, the worker doses, and occupational exposures, that was funded at $565,000 in 2000, and the 2001 budget, it's $870,000. And if I look through here, there's a good reason for that increase, I don't have it indicated in my notes.

MR. HORNBERGER: That's okay. Because I --

MR. OTT: It's about the same.

MR. HORNBERGER: It's about the same, perhaps a little lower.

MR. OTT: Yeah, but it's about two million in the waste arena. It's about a half a million in materials, and about a half a million in reactors. Total, about $3 million, if you take out the fluctuations caused by things like National Academy and RESRAD and DandD.

MR. HORNBERGER: Okay. We don't have a lot of time, but we'll have a round of questions.

MR. WYMER: That was great.

MR. OTT: I felt like I kept losing myself.

MR. GARRICK: Well, I think I'll pass, too. I just want to ask what --

MR. HORNBERGER: If you're going to ask something, you better ask it.

MR. OTT: This is a mutually ....

MR. GARRICK: How far in the future do you look when you do your planning for research?

MR. OTT: Right now, we're looking at five years.

MR. GARRICK: Five years.

MR. OTT: In the past, we've looked five years ahead, but as budgets shrunk, projects got stretched out, instead of cutting projects, we would tend to slide dollars over, and all of a sudden your planning window became shorter, because you weren't able to start new things. But we are deliberately, in this plan, trying to look five years into the future. We're trying to do more in terms of projecting and participatory needs.

MR. GARRICK: Okay.

MR. HORNBERGER: Stan? John?

MR. LARKINS: You said that one area that ... pathway analysis, are there any other areas that you think should be funded?

MR. OTT: Well, I think that was one of the most obvious ones. To a certain extent, a lot of it is going to depend on this -- the results of our demonstration project at Nada Reda, and on the results of the absorption project.

If it's true that we can do a much better job with geochemistry, with making ... models, it's also true that we probably don't have the right data to do it at the majority of sites. If somebody goes in and pulls up a soil sample and there's a KD in the laboratory, and then goes back, you're not going to have the information out of that sample, to then go back and say, well, I don't want to do a KD, I want to do something else. We need to know something about what's in that soil, in terms of the primary minerals that are present, because the minerals are going to be the things that are critical in determining how things are absorbed.

So in the long run, to a certain extent, it depends on certain research. And I should point out, and you'll see this when you look at it. One of the things in the absorption project is going to look at is costs. We want to know whether we can efficiently, effectively and cost effectively make these kinds of changes.

Part of that depends on how much of the burden is assumed by regulatory agencies, and how much of its assumed by the individual developers.

The -- we still anticipate that need for a platform to do complex sites. So I expect that we will continue to meet the fund work in that area. I can't really identify anything more right now.

We've asked the staff, and they've given some input, but we haven't really had a chance to collate ... Sorry. I wish I could give you a better answer right now.

MR. HORNBERGER: Okay. We're going to move on. Thanks very much, Bill. I turn it back to you, Mr. Chairman.

MR. GARRICK: Okay. I think that in order to accommodate changes and adjustments, we'll take a five minute break. We no longer need the court reporter for the next session. Just a short break.

(Conclusion of proceedings.)

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CERTIFICATION OF TRANSCRIPT

I, Ellen Walters, hereby certify that this is the transcript of the porceedings held before the U.S. Nuclear Regulatory Commission in the matter of the 123RD MEETING OF THE ADVISORY COMMITTEE ON NUCLEAR WASTE, at SAN ANTONIO, TEXAS, on November 28, 2000, and that this is a full and correct transcript of the porceedings.

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Ellen Walters, CSR

My Commission Expires: 12/31/01

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